UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Hailstorms evidence from smart-phone users:

Crowd-sourced hail size data over Switzerland

Noti Pascal

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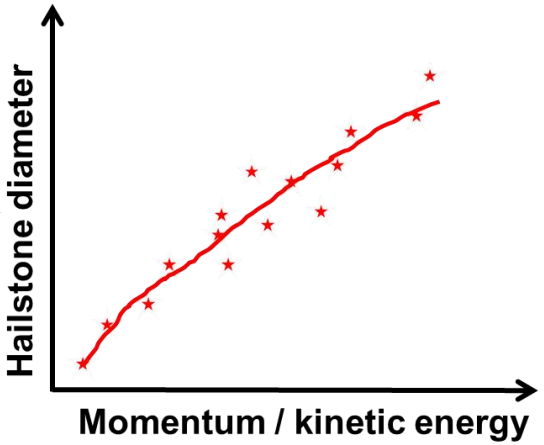
Bern 21.04.2017

Motivation & Objectives

- Is crowd-sourcing data reliable and usable for the verification of radar-based hail detection algorithms?
- Do the reported hailstone sizes from the crowd-sourcing and measurements from hail sensors correlate with radar-derived HS (at 5 minute resolution)?
- June-August 2015 and April-August 2016

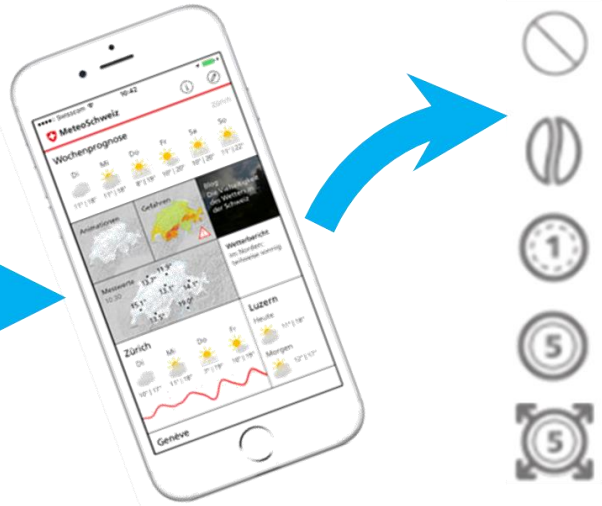
Data & Methods

inNET Monitoring AG



10 stations
835 impacts

Crowd-source data



27’031 reports from MeteoSwiss

3’626 reports from Mobiliar

Data & Methods

$\Delta z = ET45 - H0$

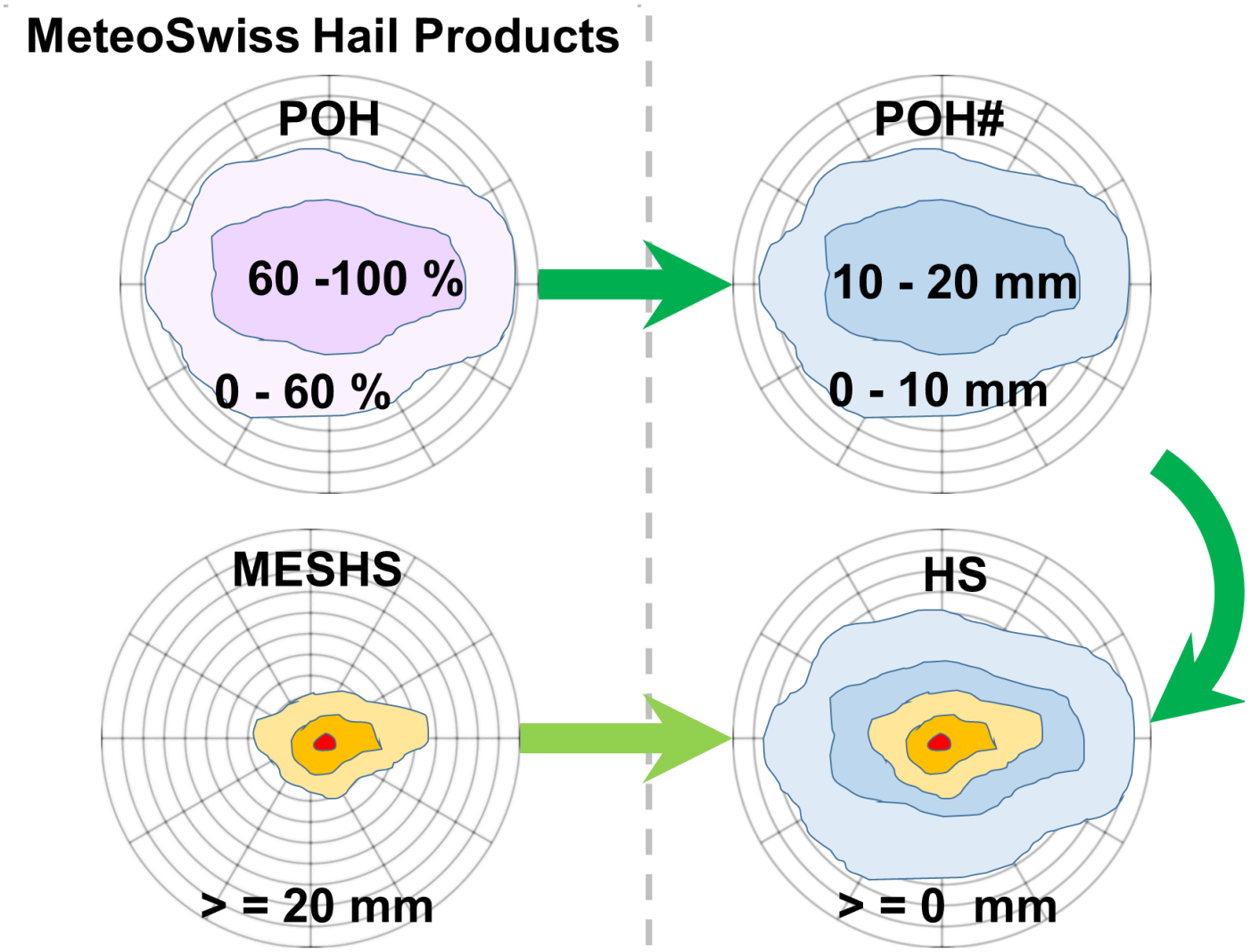
$\Delta z > 1.65\ km \rightarrow 0\%$

$\Delta z > 5.5\ km \rightarrow 100\%$

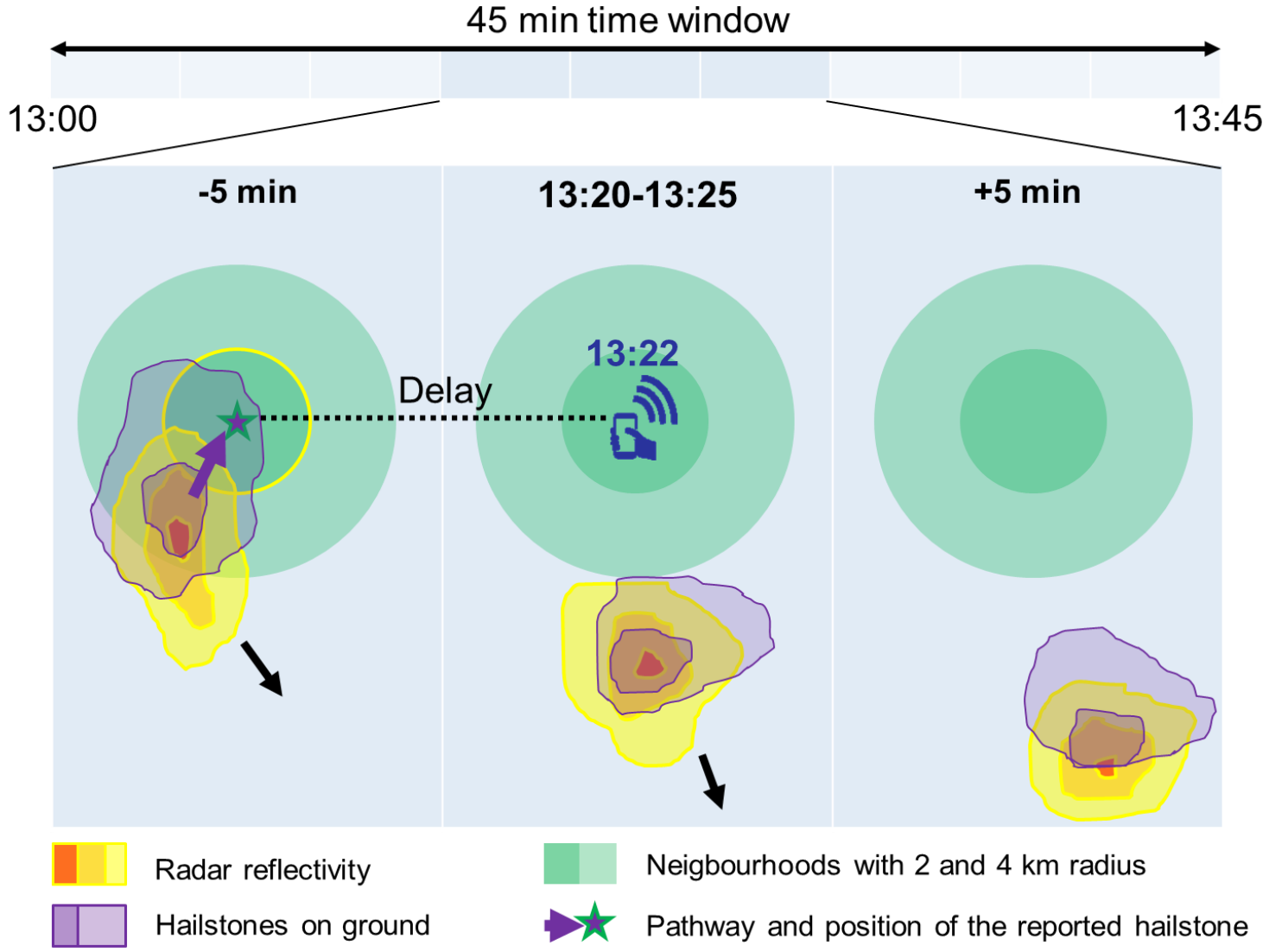
Waldvogel et al. (1979)

$\Delta z = ET50 - H0$

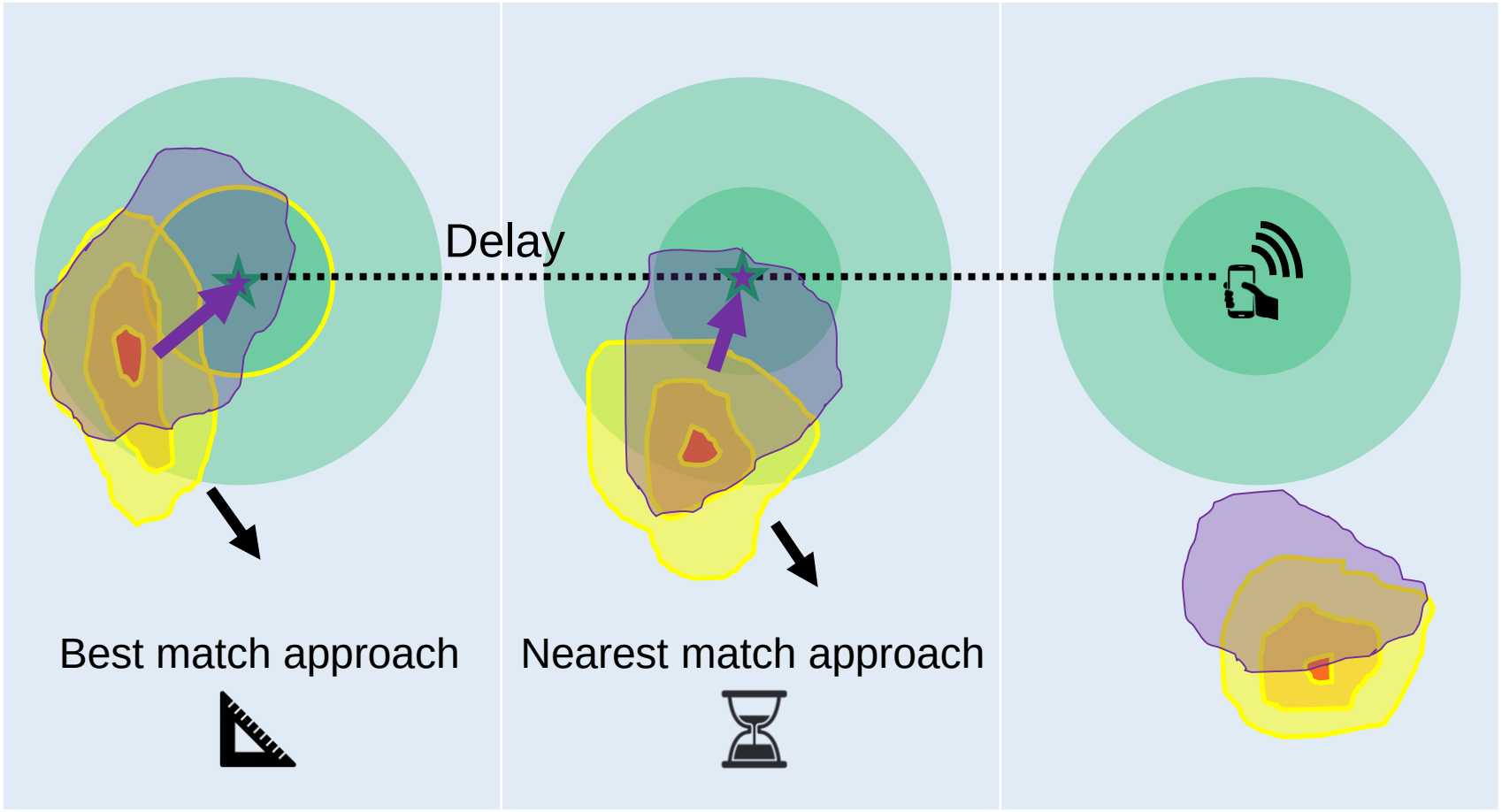
Treloar. (1998)

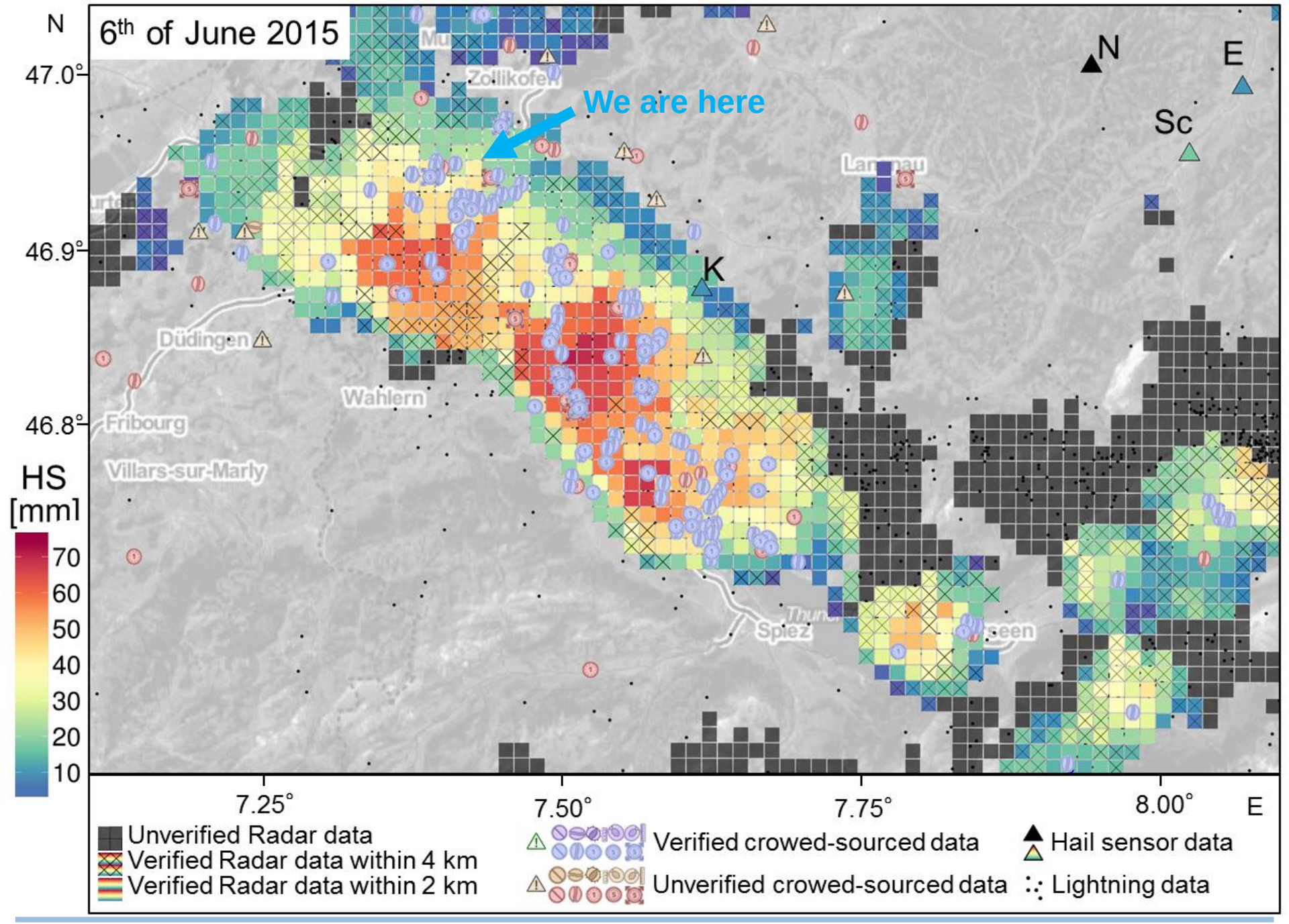


Data & Methods

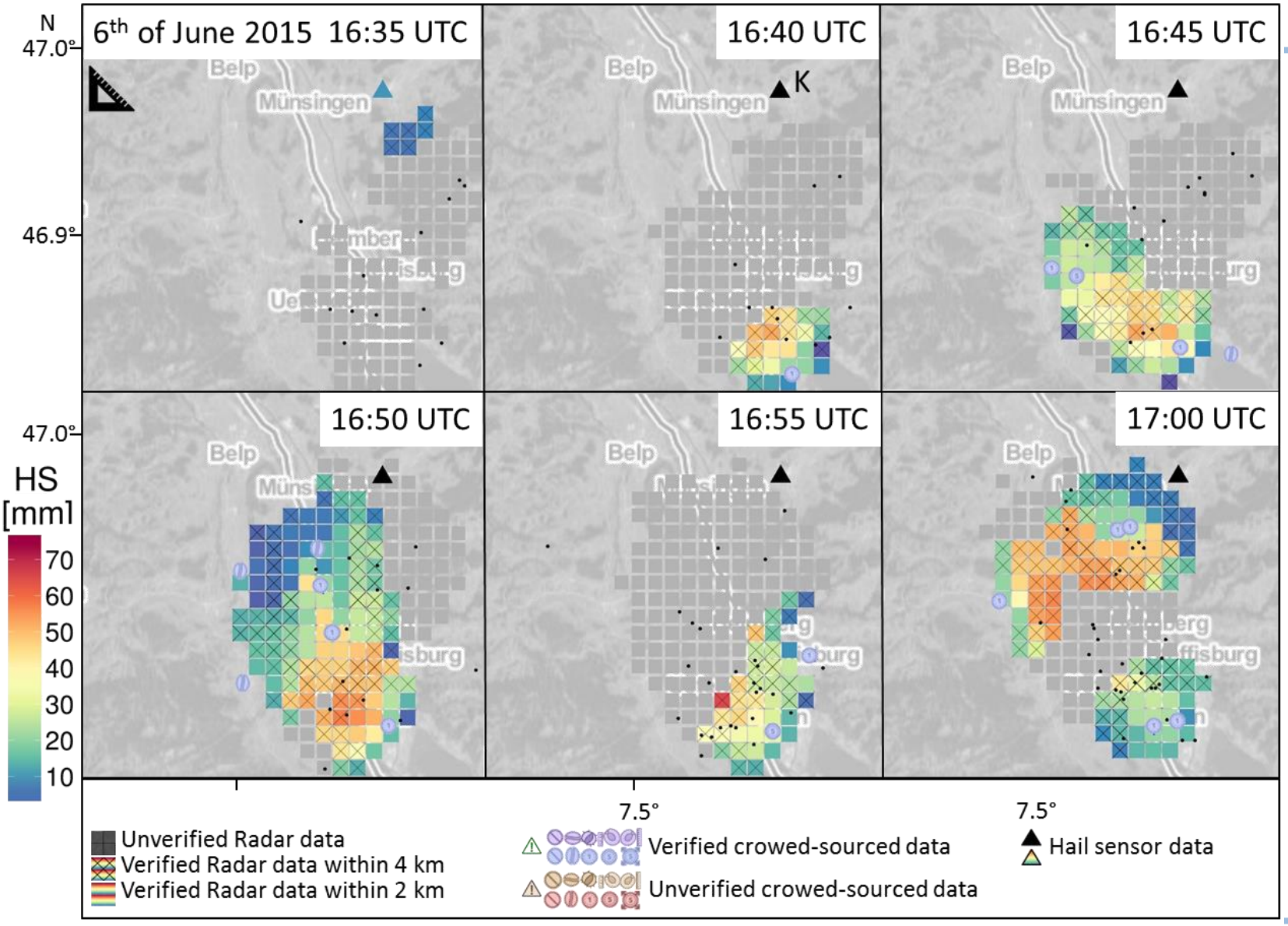


Data & Methods




6th of June 2015
We are here
N
47.0°
46.9°
46.8°
HS [mm]
70
60
50
40
30
20
10
N
E
Sc
K
Zollikofen
Lanzenau
Düdingen
Wahlern
Fribourg
Villars-sur-Marly
Spiez
7.25°
7.50°
7.75°
8.00°
E
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data

Results


6th of June 2015 16:35 UTC
16:40 UTC
16:45 UTC
16:50 UTC
16:55 UTC
17:00 UTC
Belp
Münsingen
N
47.0°
46.9°
7.5°
HS [mm]
70
60
50
40
30
20
10
Unverified Radar data
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Hail sensor data

Results

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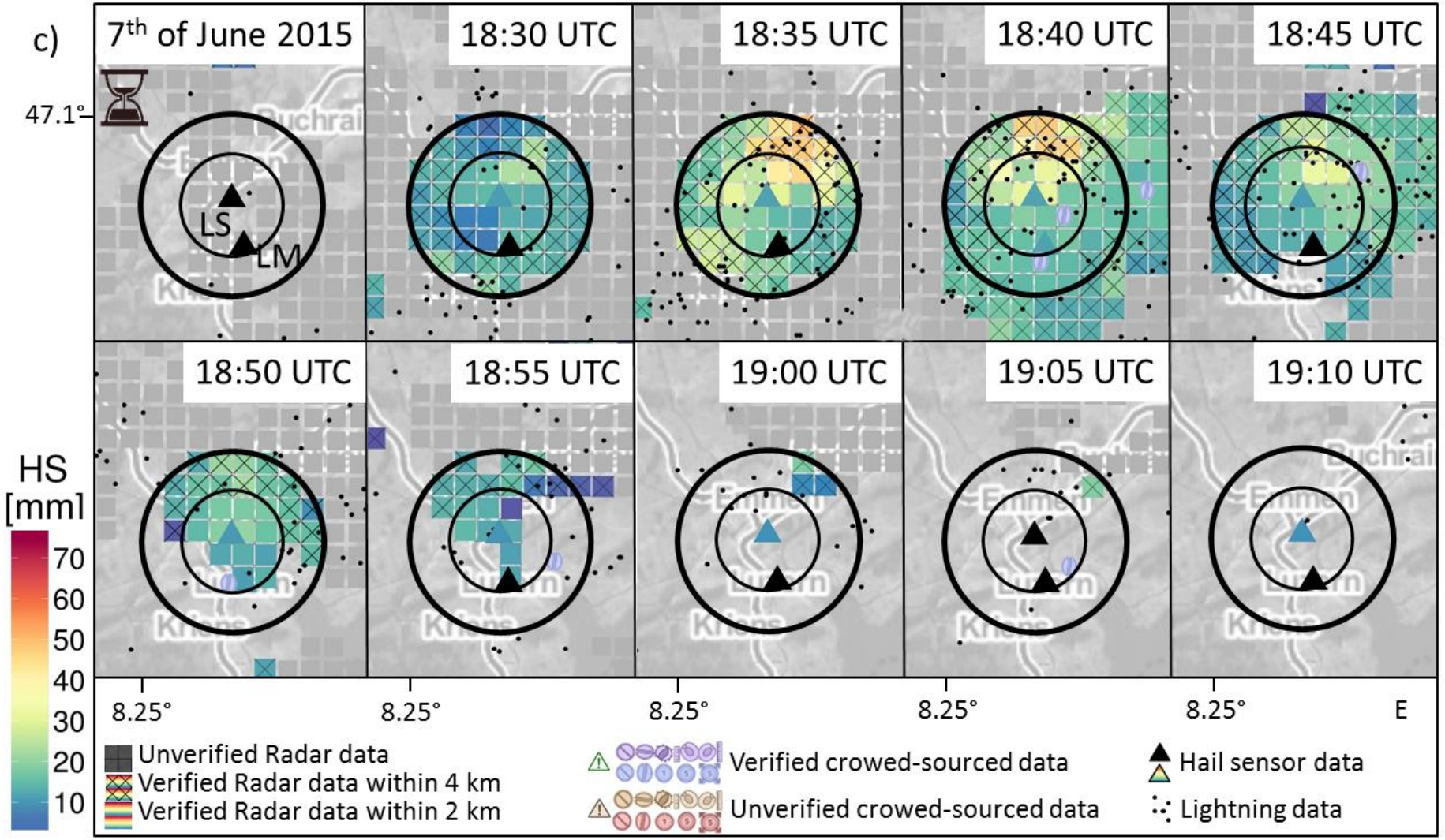
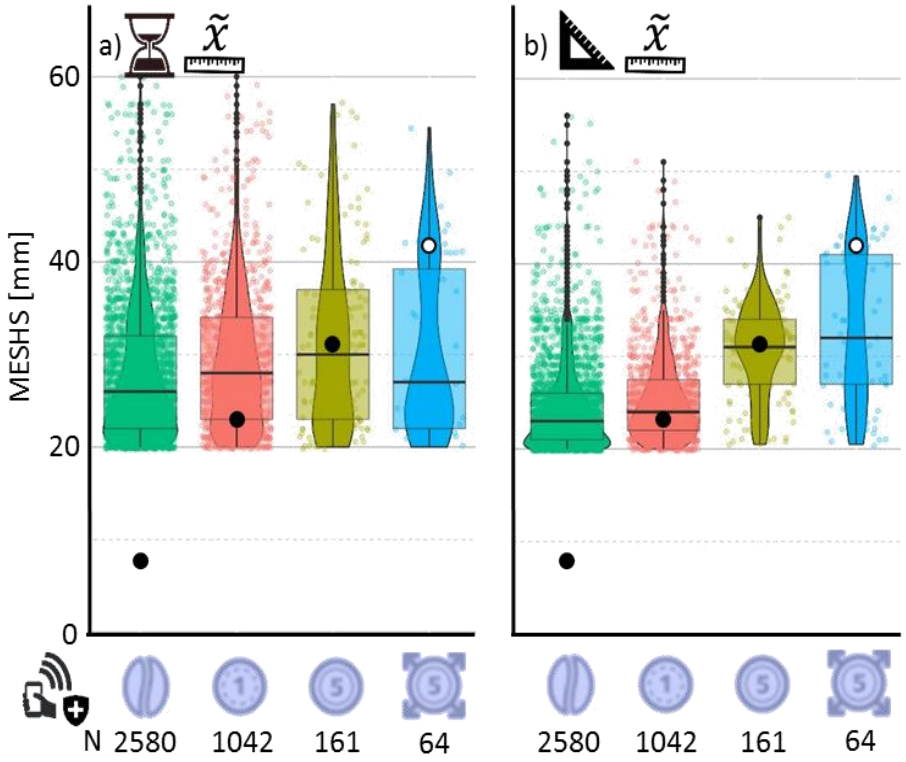
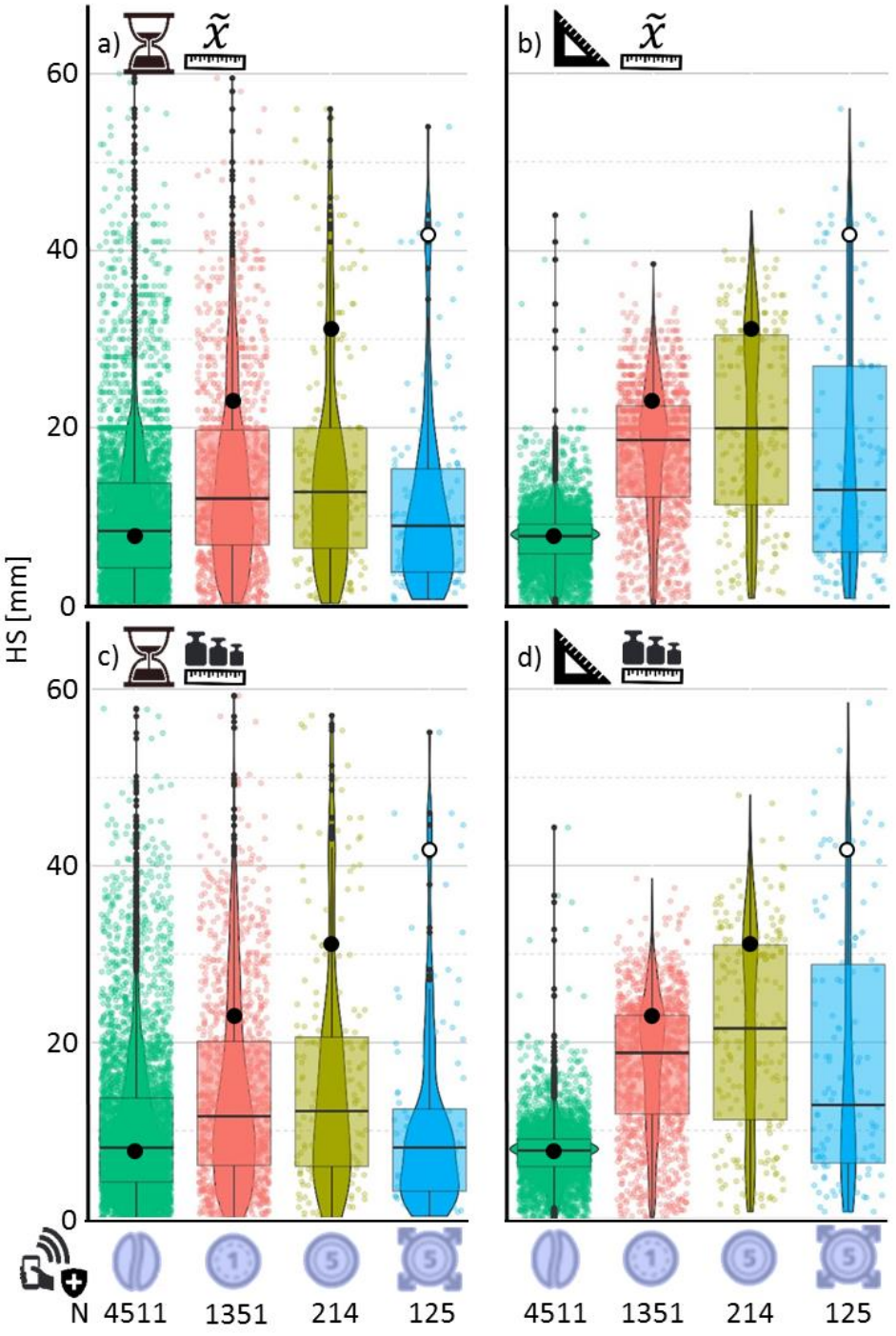


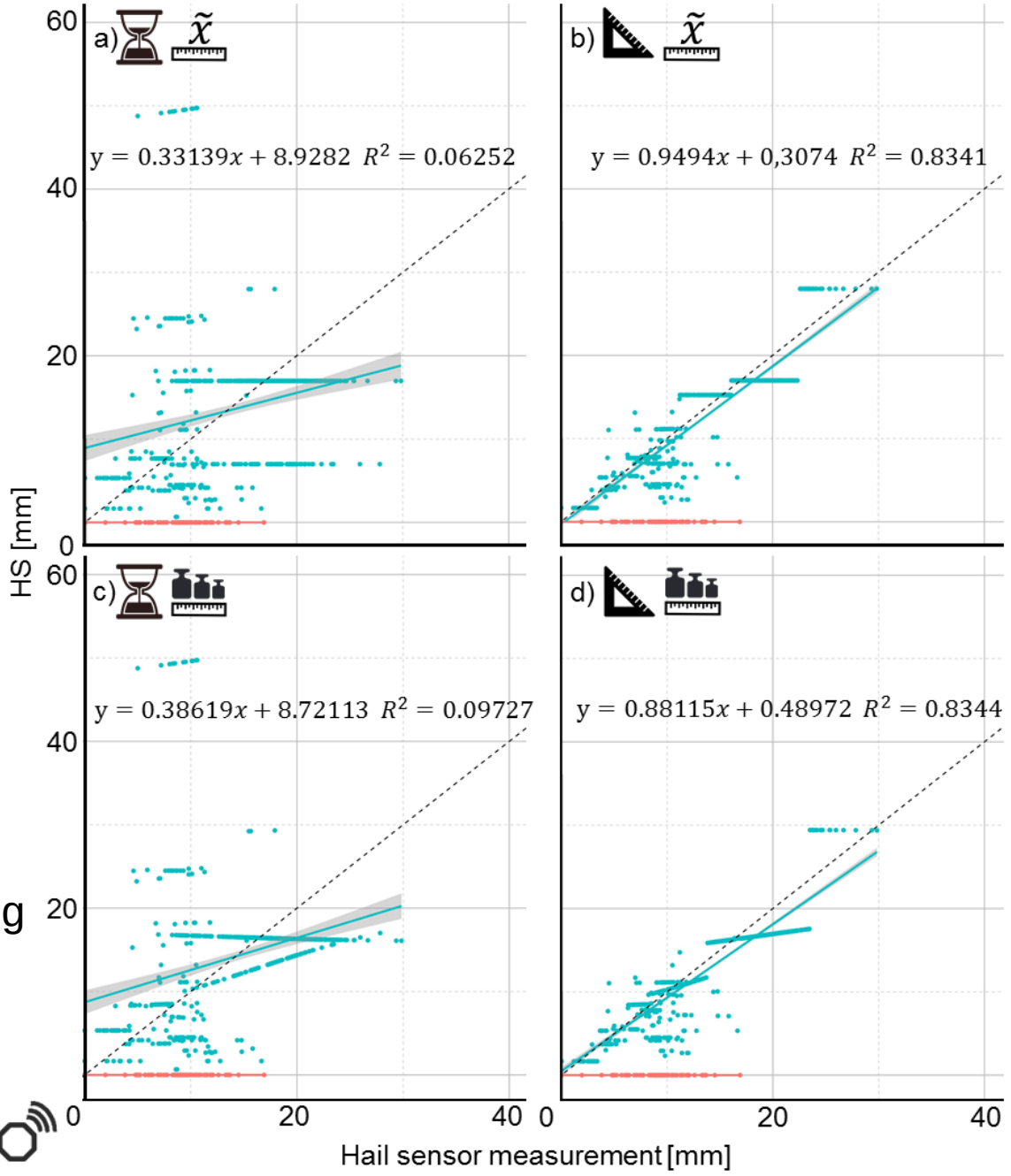




- Best match approach
- Nearest match approach
- Inverse distance weighting
- $\tilde{x}$ median

27 % matched reports in total

Results



- Best match approach
- Nearest match approach
- Inverse distance weighting
- $\tilde{x}$ median

Conclusions

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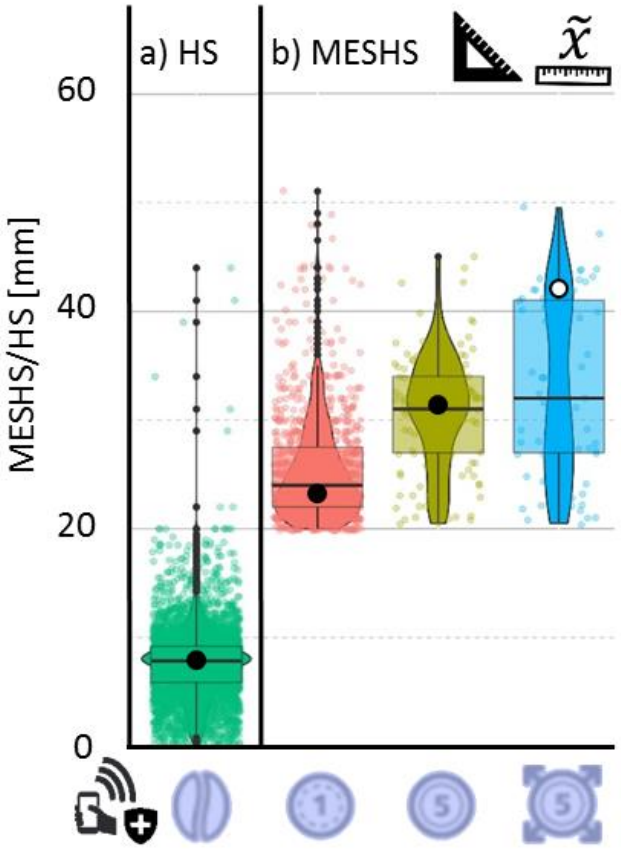
- Matched hail reports 27 %
- Many false reports
- High spatial and temporal verification
- Small hail correlate with HS
- Medium sized hail correlate with MESHS



Outlook

- Temporally longer dataset improves statistics
- Lists of trusted and unreliable users
- More reportable sizes
- Big potential for thunderstorm nowcasting, weather monitoring and for the assessement of insurance damage claims.

Thanks for your attention

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Literature

- Betschart, M., and A. Hering (2012), Automatic hal detection at MeteoSwiss: Verification of the radar-based hail detection algorithms POH, MESHS and HAIL. Arbeitsbericht MeteoSchweiz Nr. 238, http://www.meteoschweiz.admin.ch
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- Koole, M., and P. Siegmund (2016), Evaluating the quality and usability of crowd-sourced weahter data, in *EGU General Assembly Conference Abstracts*, vol. 18, 3959.
- Muller, C., L. Chapman, S. Johnston, C. Kidd, S. Illingworth, G. Foody, A. Overeem, and R. Leigh (2015), Crowdsourcing for climate and atmospheric science: Current status and future potential, *International Journal of Climatology, 35* (11), 3185-3203.
- Nisi, L., O. Martius, A. Hering, M. Kunz, and U. Germann (2016), Spatial and temporal distribution of hailstorms in the alpine region: A long-term, high-resolution, radar-based analysis, *Quaterly Journal of the Royal Meteorological Society, 142* (697), 1590-1604.
- Treloar, A. (1998), Vertically integrated radar reflectivity as an indicator of hail size in greater sidney region of Australia, *American Meteorological Society, 19th Conference on Severe Local Storms*, 48-51.
- Waldvogel, A., B. Federer, and P. Grimm (1979), Criteria for the detection of hail cells, Journal of Applied Meteorology, 18 (12), 1521-1525.

Appendix

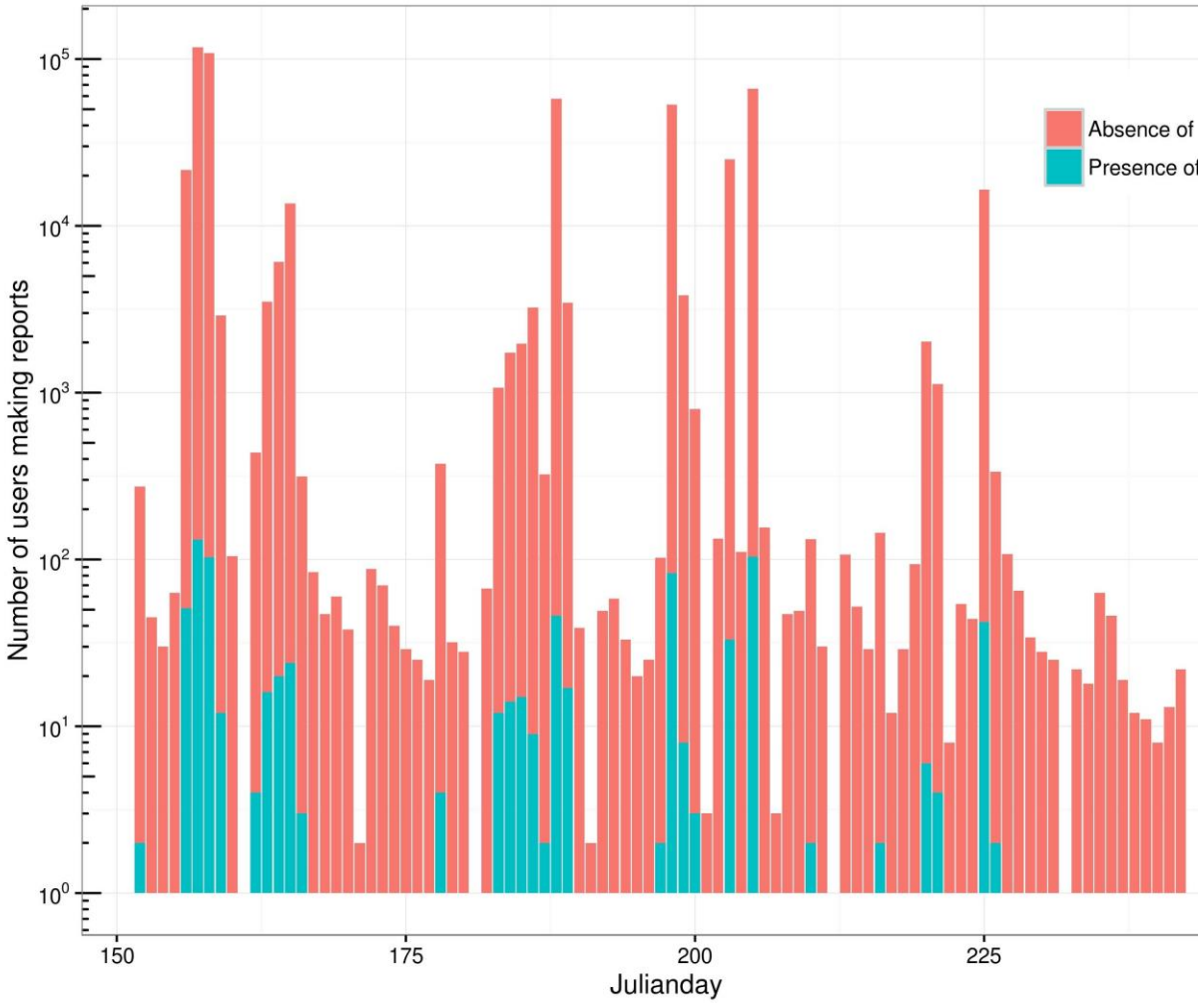
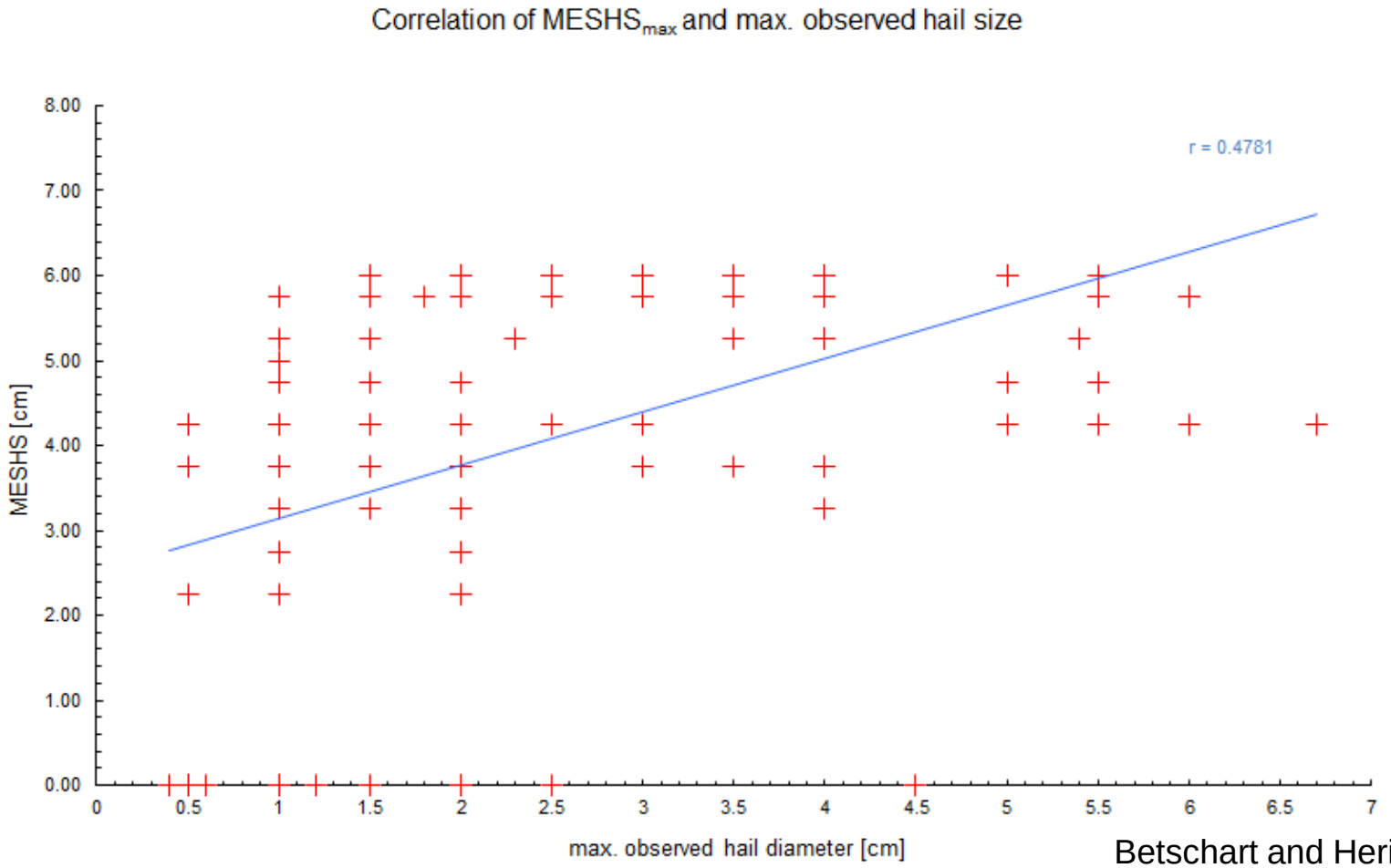


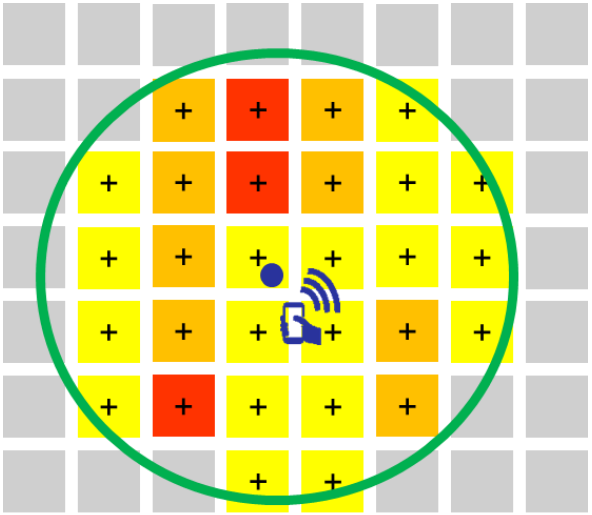
Figure 8: Number of users over time

Appendix



Betschart and Hering 2012

Appendix



Median

$\tilde{x}$

Inverse Distance Weighting

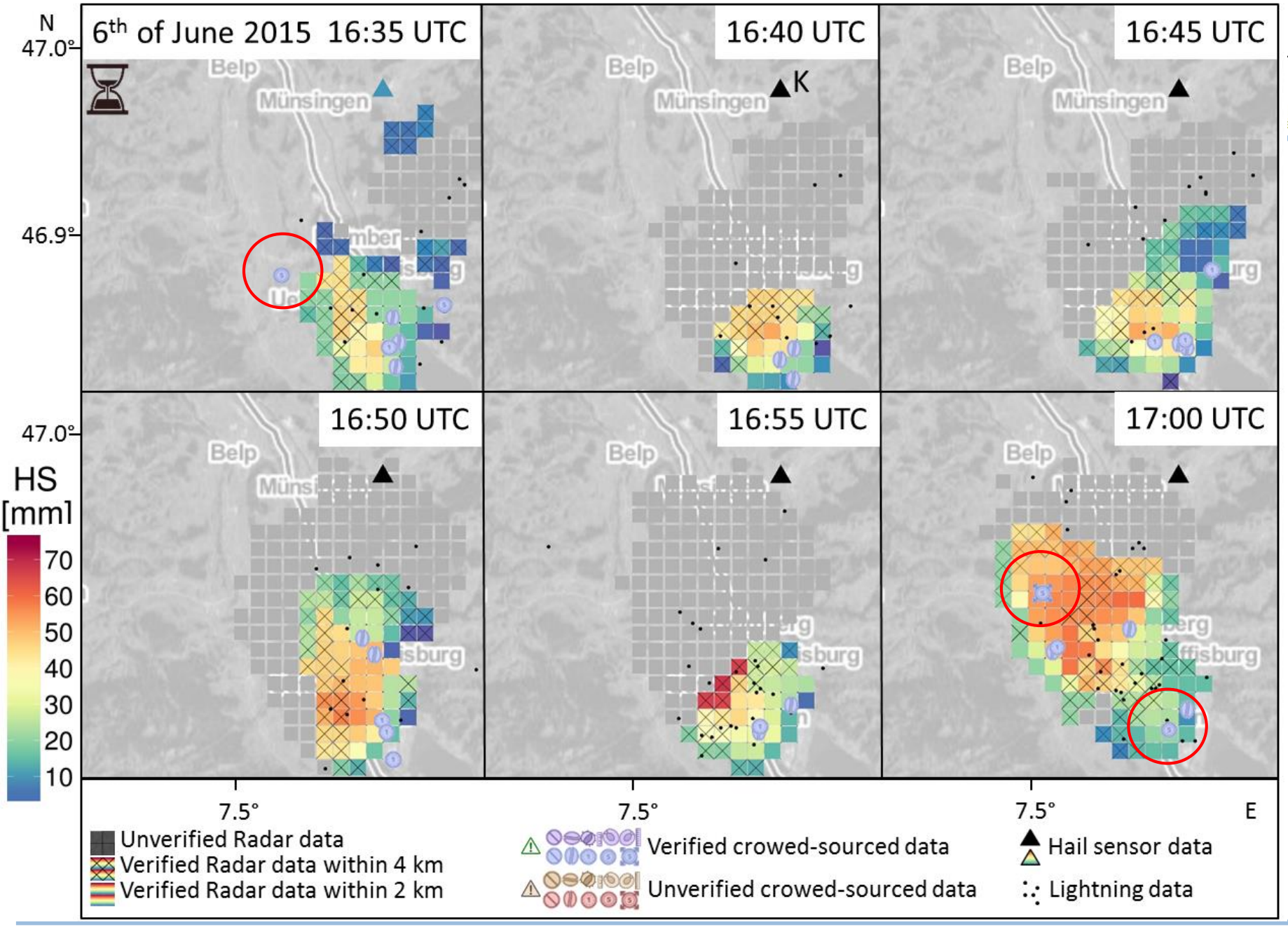
$$IDW = \frac{\sum_{i=1}^{n} \frac{x_i}{d_i^p}}{\sum_{i=1}^{n} \frac{1}{d_i^p}}$$

p:= 2 for

p:= 3 for

p:= 4 for

p:= 5 for


N
47.0°
46.9°
47.0°
6th of June 2015 16:35 UTC
16:40 UTC
16:45 UTC
16:50 UTC
16:55 UTC
17:00 UTC
Belp
Münsingen
HS
[mm]
70
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40
30
20
10
7.5°
7.5°
7.5°
E
Unverified Radar data
Verified Radar data within 4 km
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Unverified crowed-sourced data
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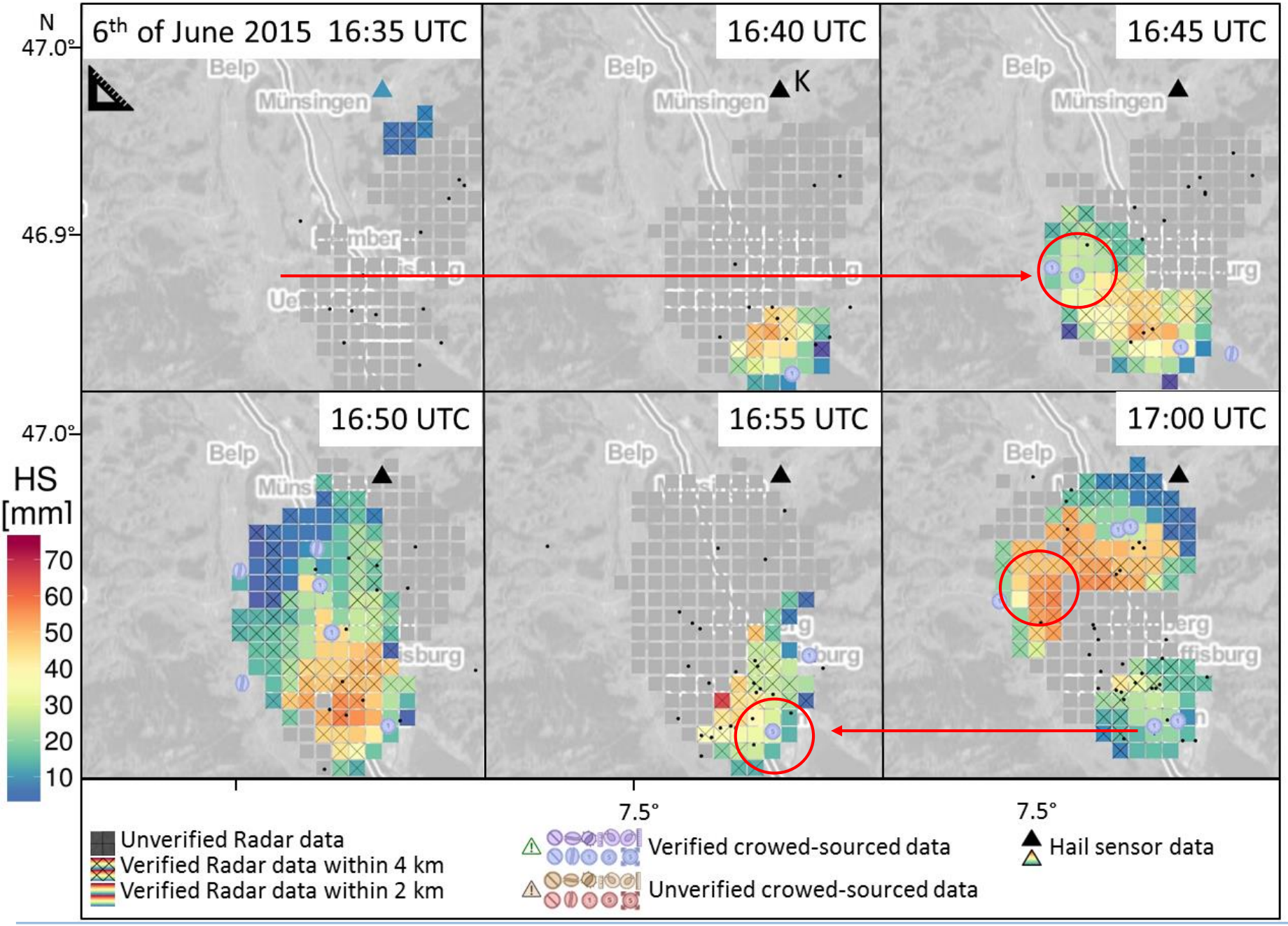
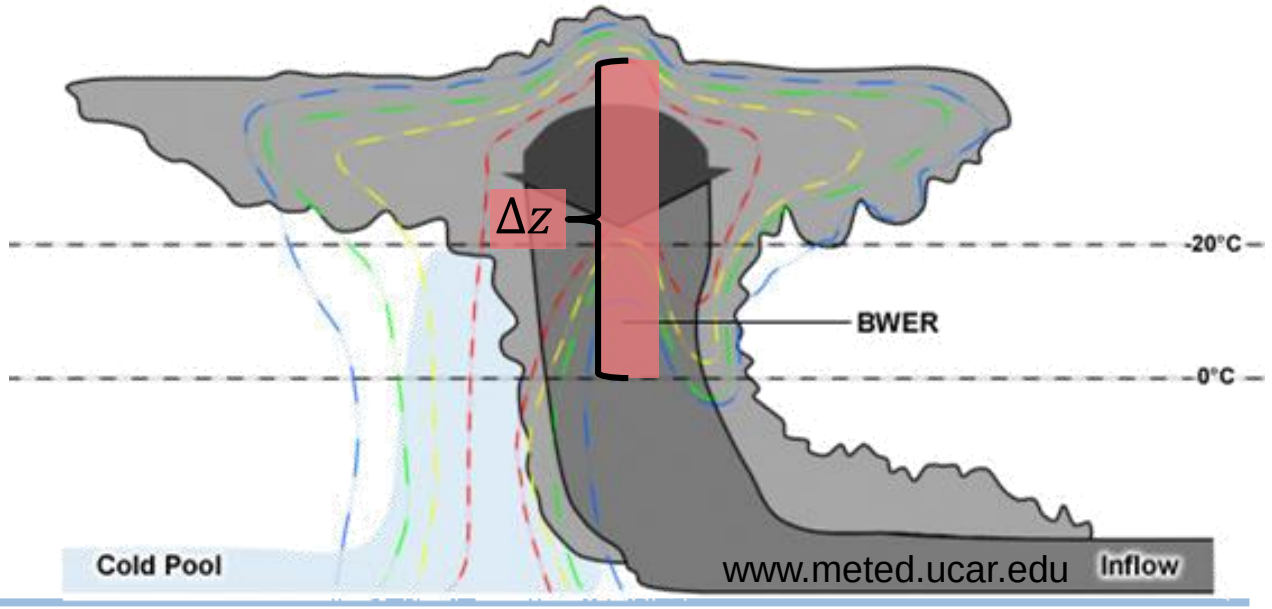
Lightning data


N
47.0°
46.9°
47.0°
6th of June 2015 16:35 UTC
16:40 UTC
16:45 UTC
16:50 UTC
16:55 UTC
17:00 UTC
Belp
Münsingen
HS [mm]
70
60
50
40
30
20
10
7.5°
7.5°
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data

Appendix

- Probability Of Hail - POH [%] Waldvogel et al. (1979)
- $\Delta z = ET45 - H0$
- $\Delta z > 1.65\ km \rightarrow 0\%\ POH$
- $\Delta z > 5.5\ km \rightarrow 100\%\ POH$

- Maximum Expected Severe Hail Size (MESHS) [mm] Treloar. (1998)
- $\Delta z = ET50 - H0$



Appendix

Crowd-sourcing

- «Crowdsourcing is the act of taking a job traditionally performed by a designed agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call» (Howe 2006)

- UK Met Office:
  - Weather Observartion Website (Muller et al. 2015)
- RNMI:
  - Weather Observartion Website (Koole and Siegmung 2016)
- NSSL of NOAA:
  - mPING project (Elmore et al. 2014)

Appendix

Crowd-sourcing

- Verification studies:
  - Texts and photos in social media (Hyvärinen and Saltikoff 2010)
  - European Severe Weather Database (Betschart and Hering 2012)

- Allocation process:
  - Time consuming
  - Costly
  - Low spatial and temporal coverage

Appendix

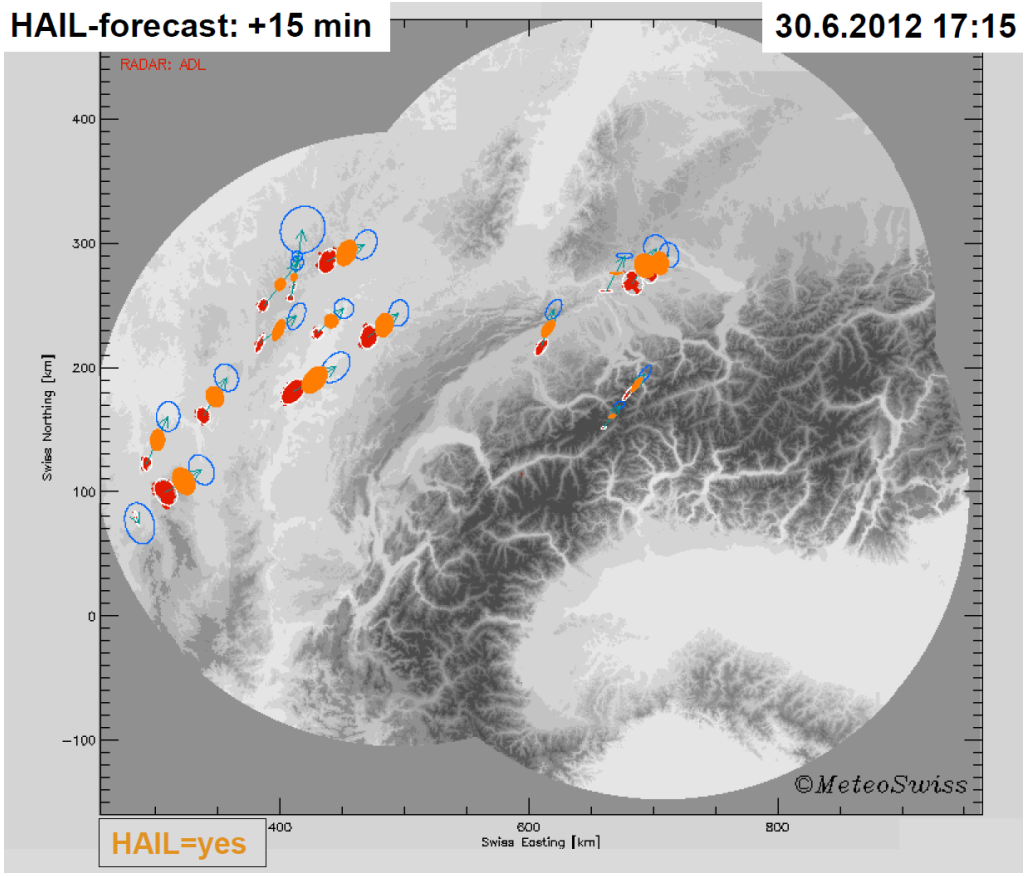
Weather Research an Forecasting model

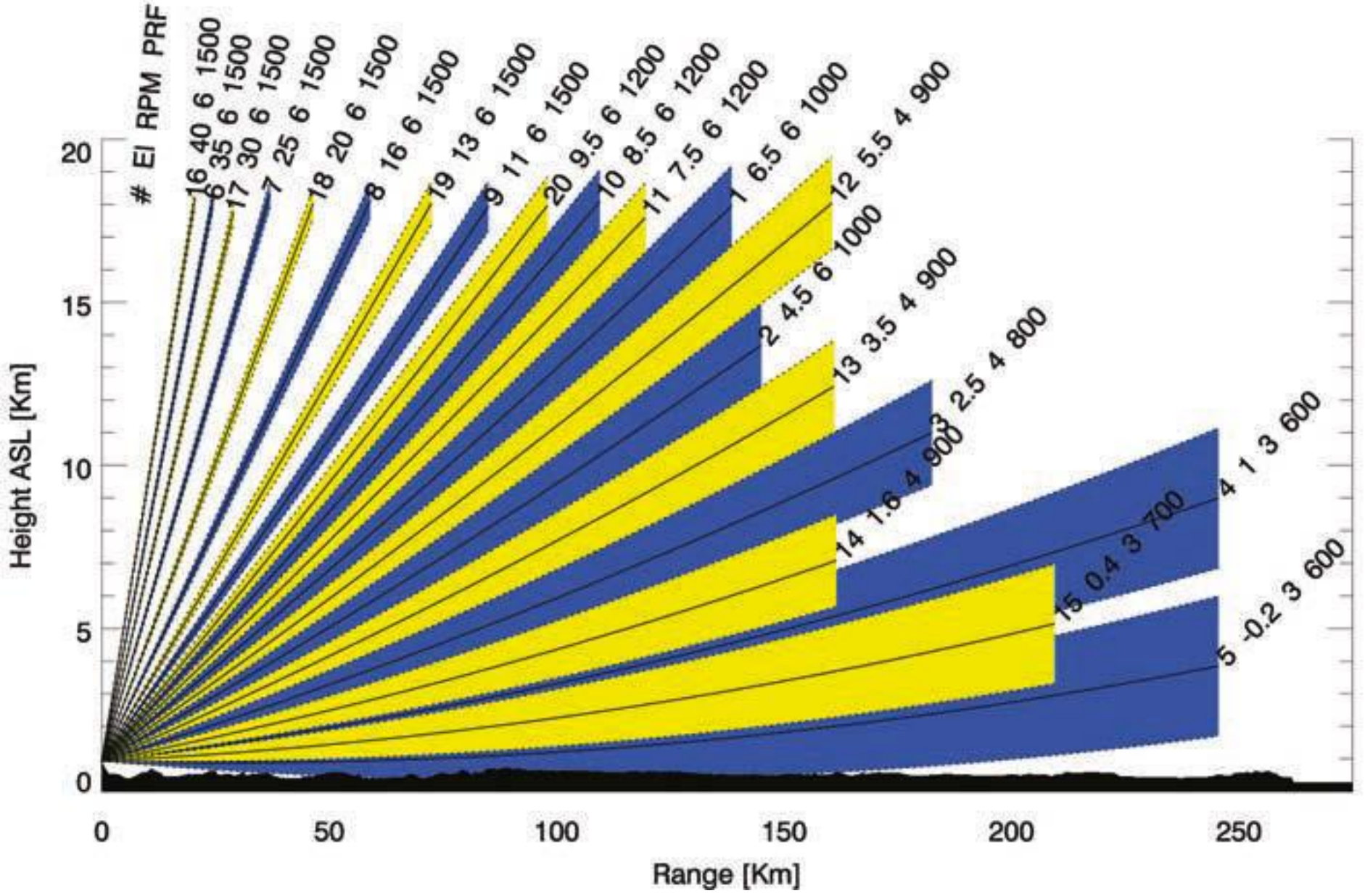
- Version 3.6.1
- Initial state from ECMWF analysis data
- 1x1 km interpolation resolution from 2.12x1.35 km model resolution
- 35 vertical levels
- New Thompson scheme and Morrison double-moment scheme
- Diagnostics HAILCAST-1D from the Air Force Weather Agency

Appendix

User feedback to hail warnings

- Warning system based on TRT for warning regions
- Volunteers
- Receive warning SMS
- (Reminding SMS)
- Send confirmation




EI RPM PRF
16 40 6 1500
6 35 6 1500
17 30 6 1500
7 25 6 1500
18 20 6 1500
8 16 6 1500
19 13 6 1500
9 11 6 1500
20 9.5 6 1200
10 8.5 6 1200
11 7.5 6 1200
1 6.5 6 1000
12 5.5 4 900
2 4.5 6 1000
13 3.5 4 900
3 2.5 4 800
14 1.6 4 900
4 1 3 600
15 0.4 3 700
5 -0.2 3 600
Height ASL [Km]
0
5
10
15
20
0
50
100
150
200
250
Range [Km]

Appendix

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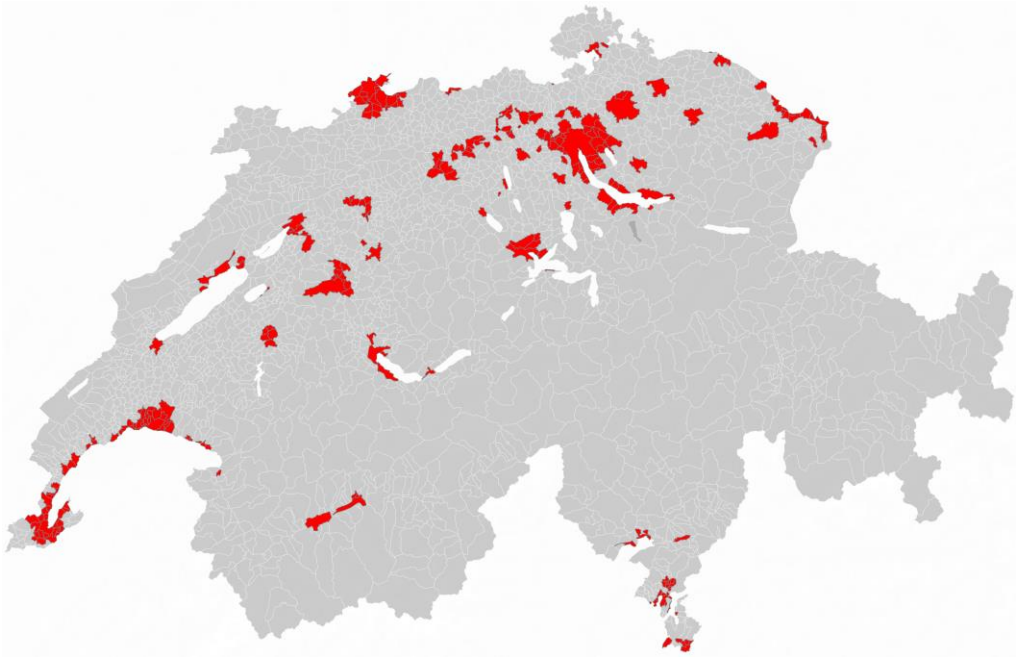
POH verification

- Swiss communities with >= 30 % settlement area
- daily resolution
- Filtered reports: >=45 dBZ
- Filtered POH: 07 UTC 19 UTC >= 80 %



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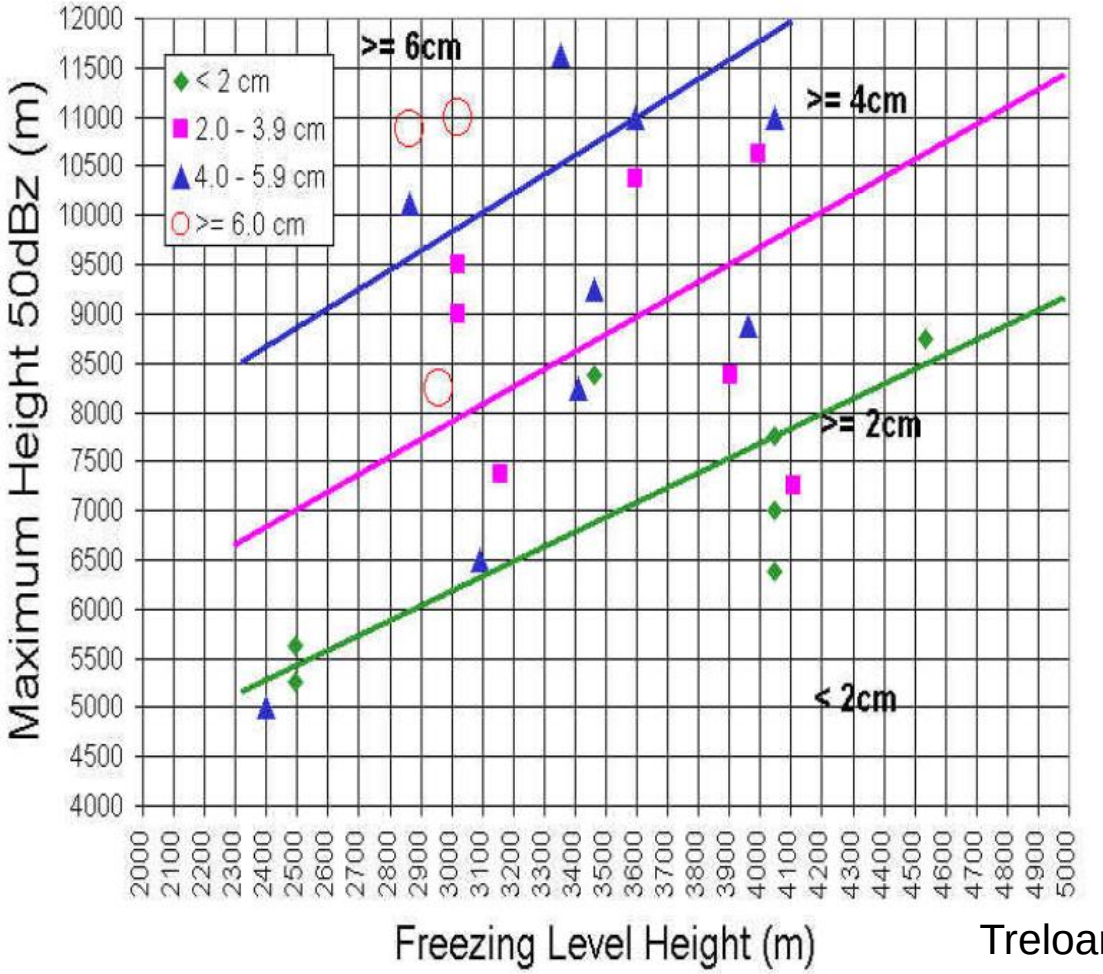
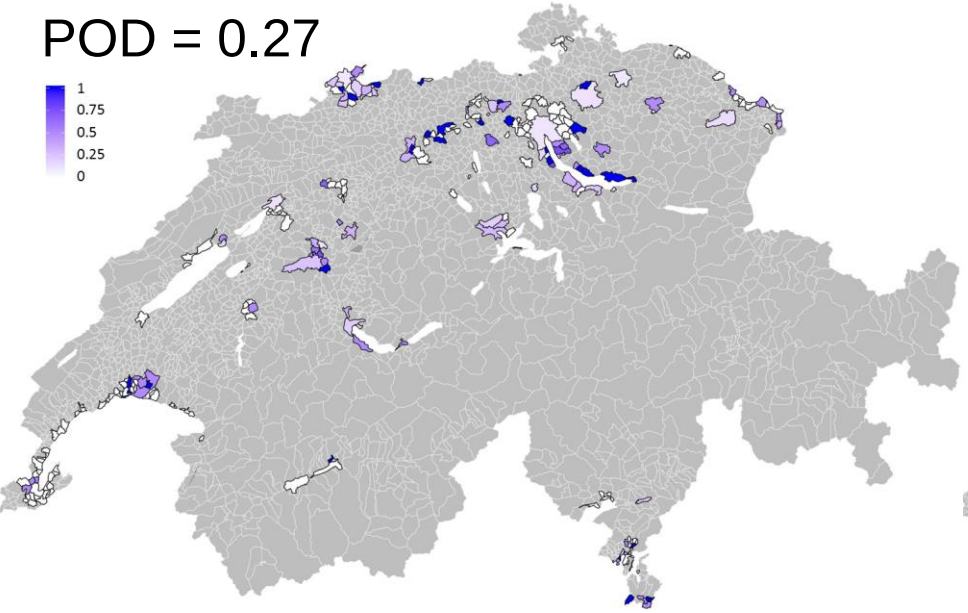
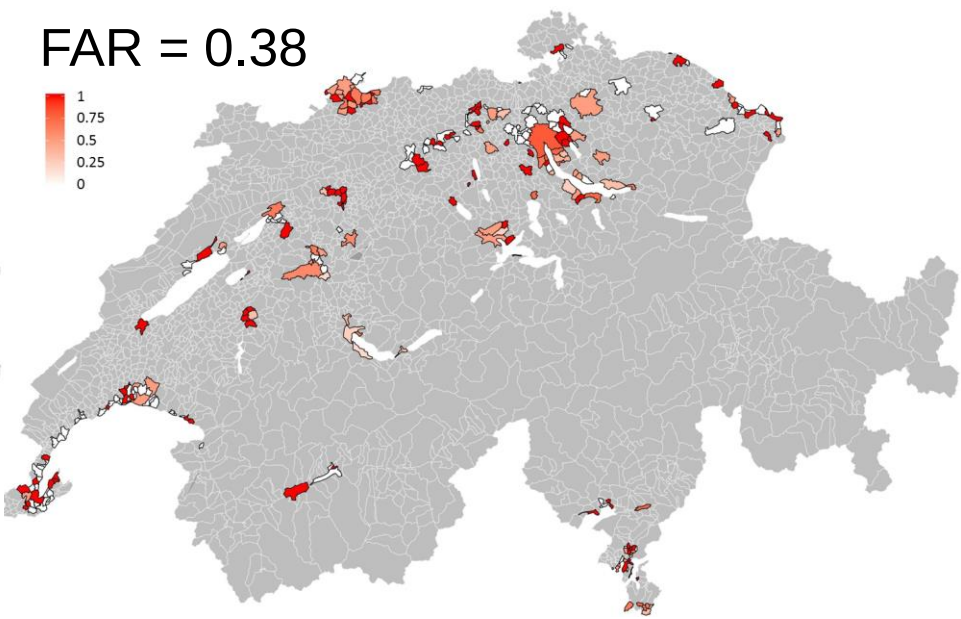


Treloar. (1998)

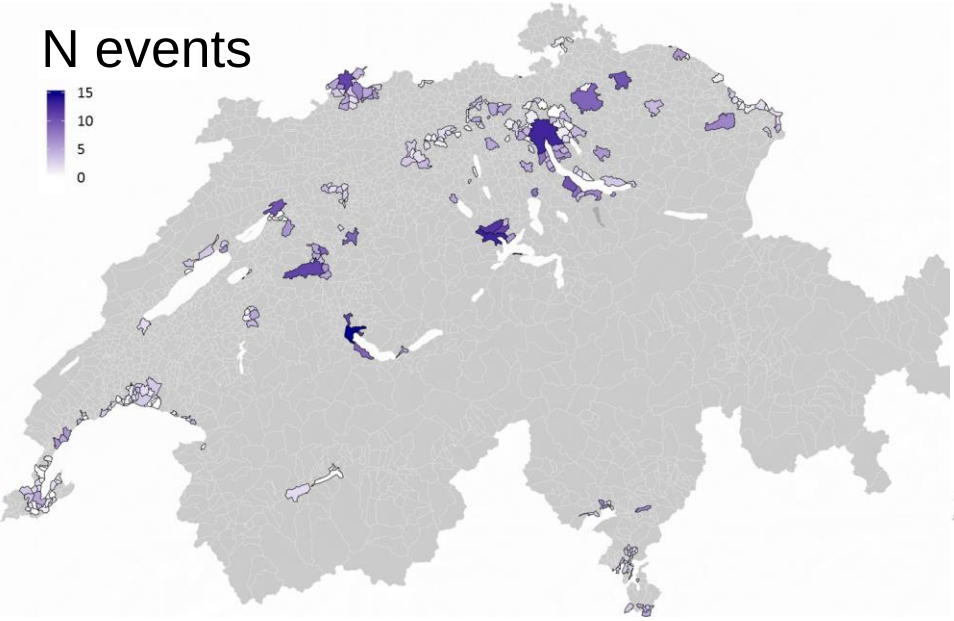
POD = 0.27



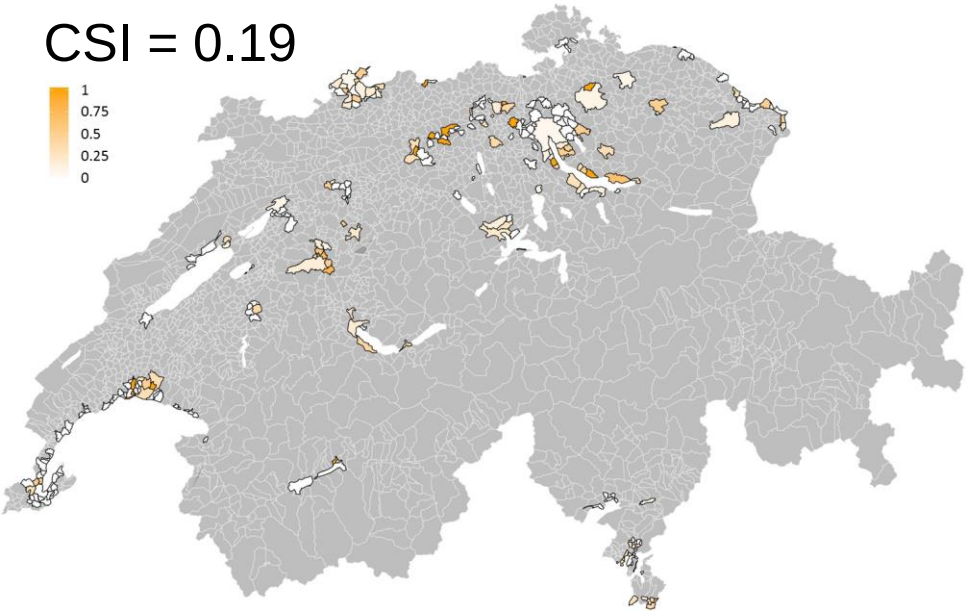
FAR = 0.38



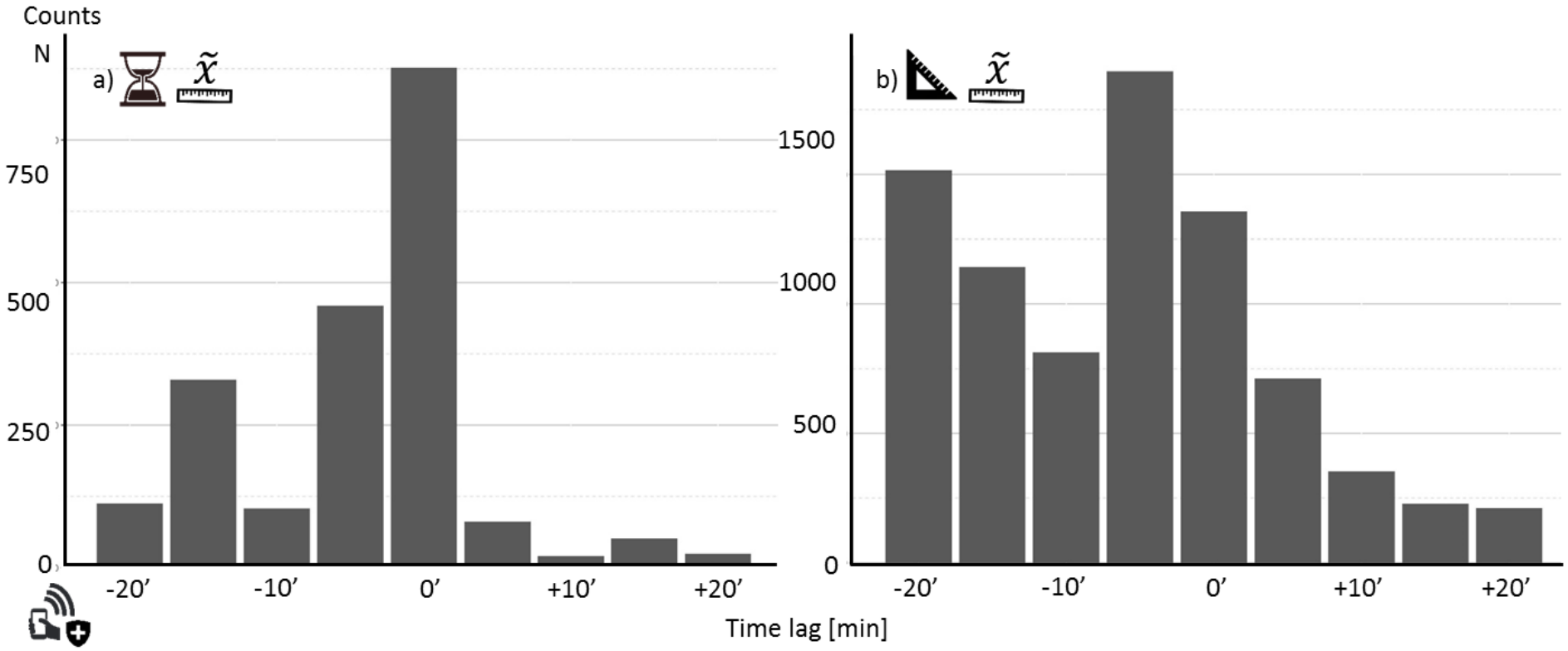
N events

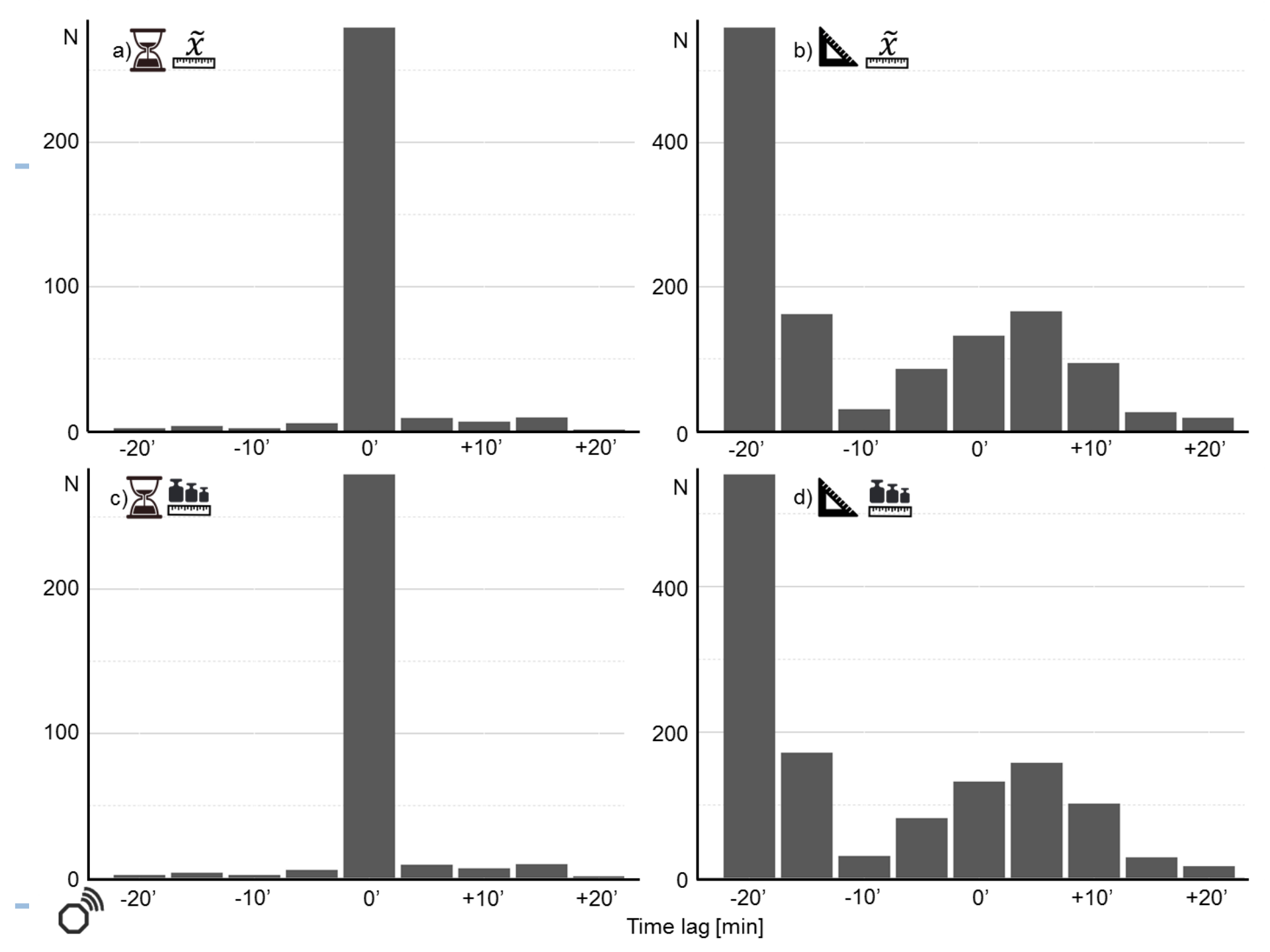


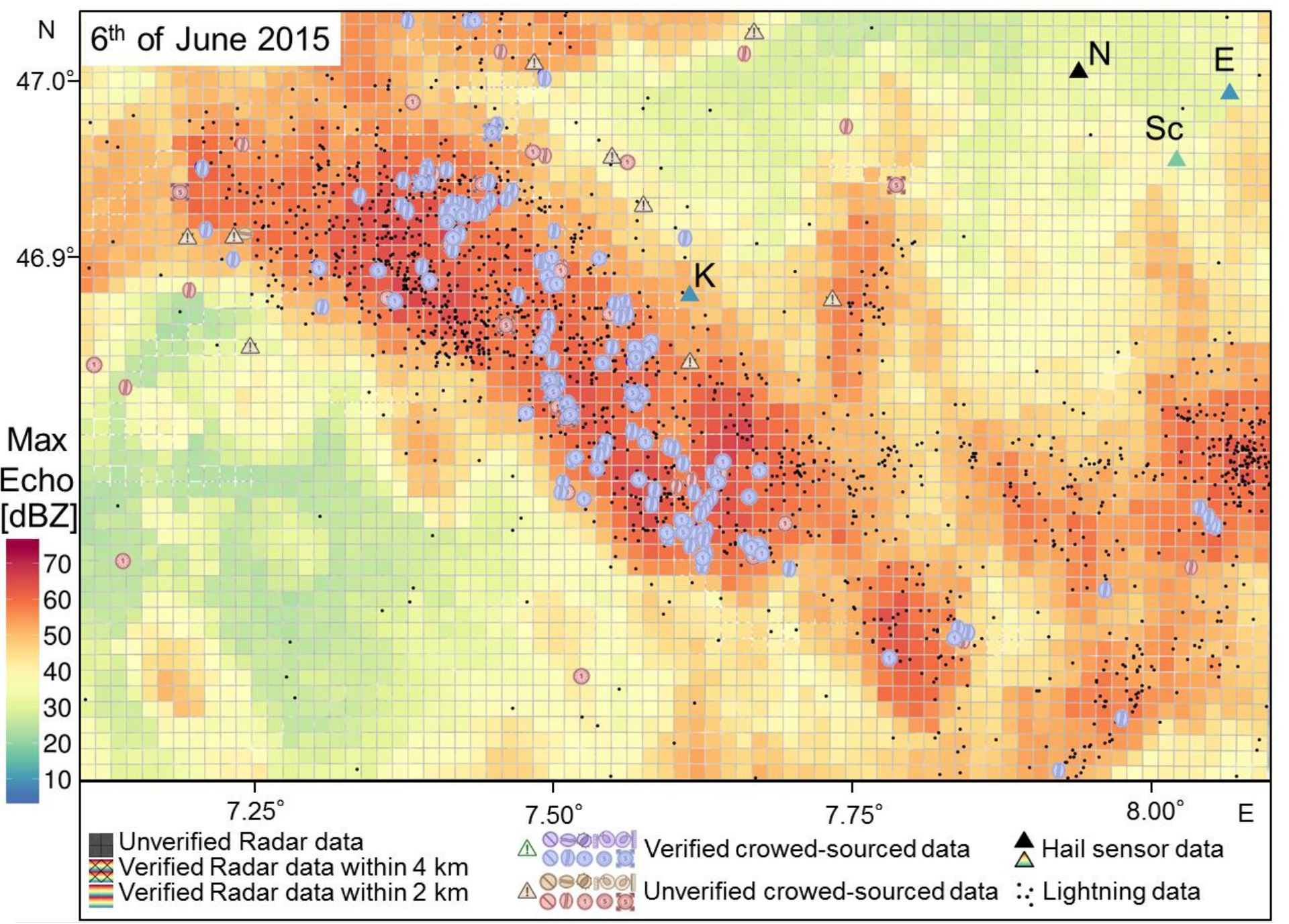
CSI = 0.19



Appendix


Counts
N
a)
$\tilde{x}$
750
500
250
0
-20'
-10'
0'
+10'
+20'
b)
$\tilde{x}$
1500
1000
500
0
-20'
-10'
0'
+10'
+20'
Time lag [min]


a)
b)
c)
d)
N
0
100
200
400
-20’
-10’
0’
+10’
+20’
Time lag [min]


N
6th of June 2015
47.0°
46.9°
N
E
Sc
K
Max Echo [dBZ]
70
60
50
40
30
20
10
7.25°
7.50°
7.75°
8.00°
E
Unverified Radar data
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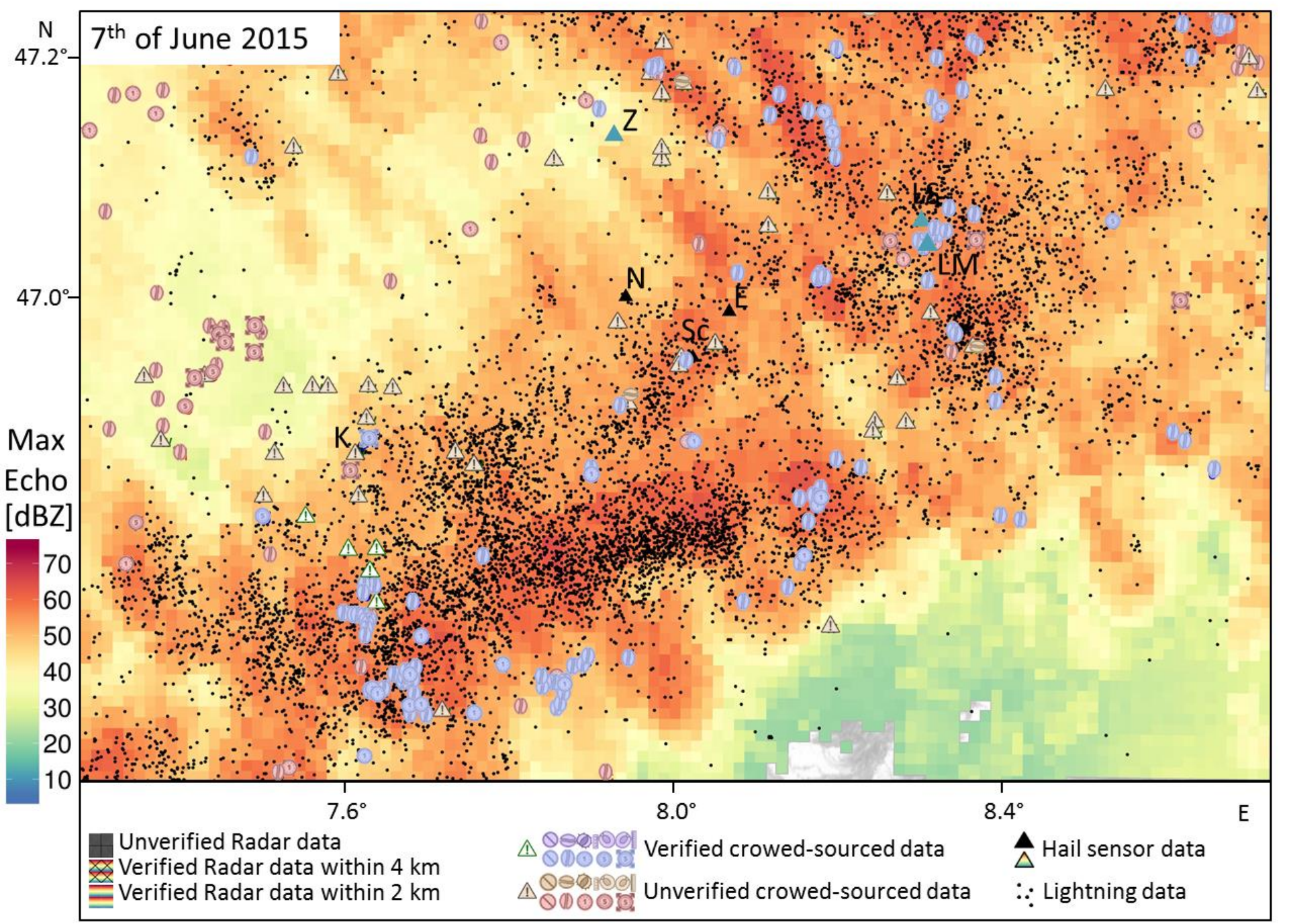
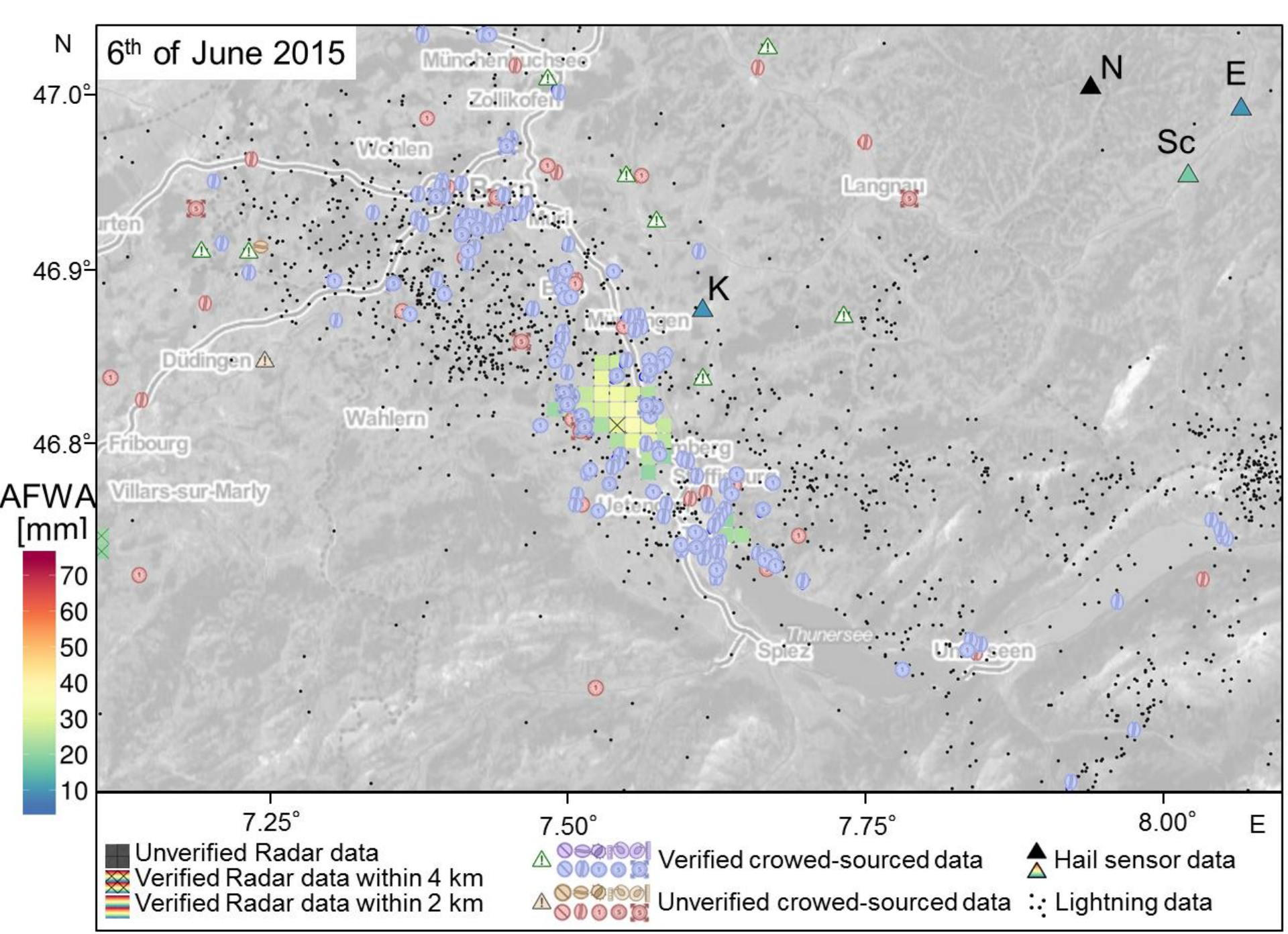
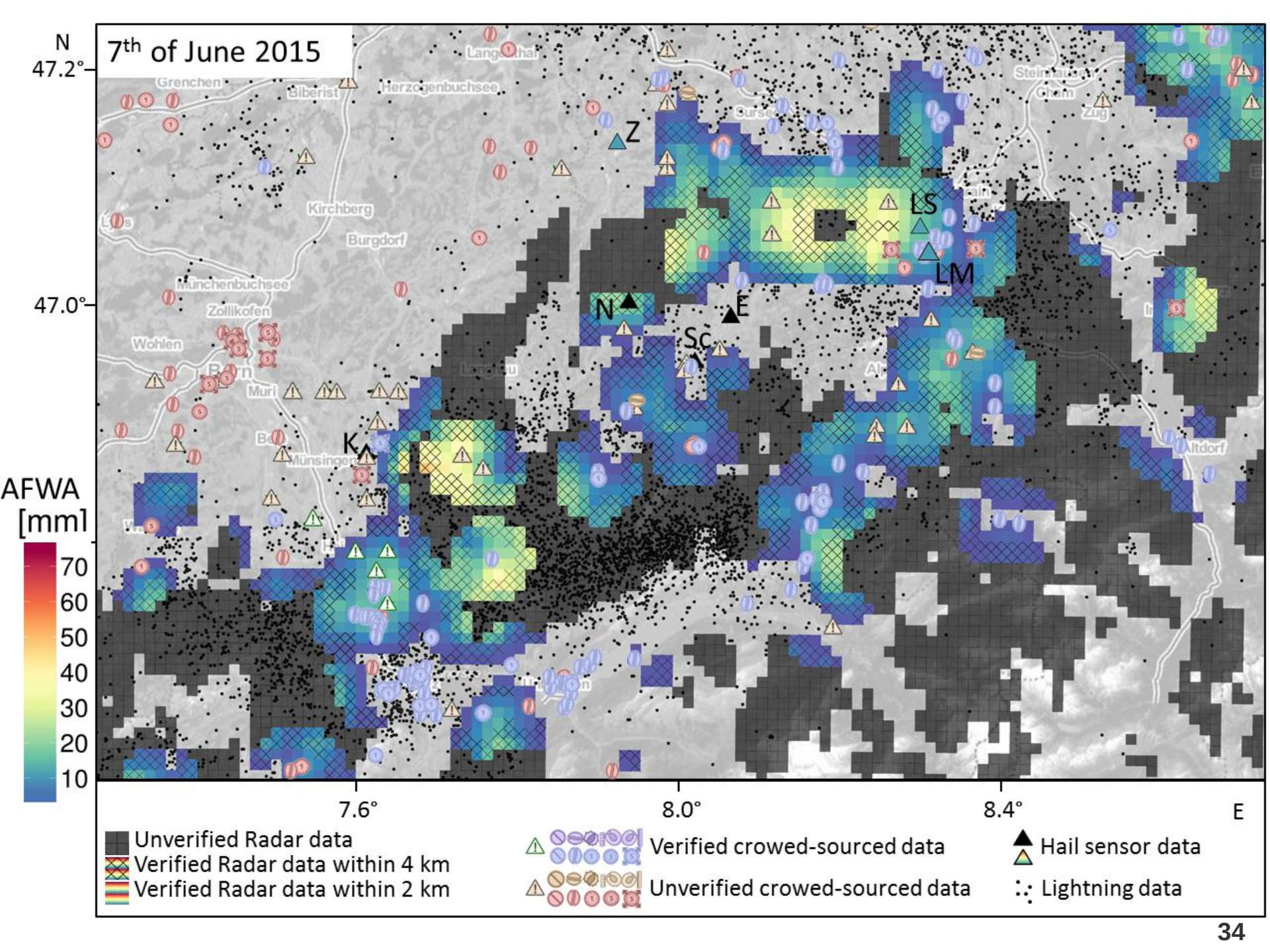
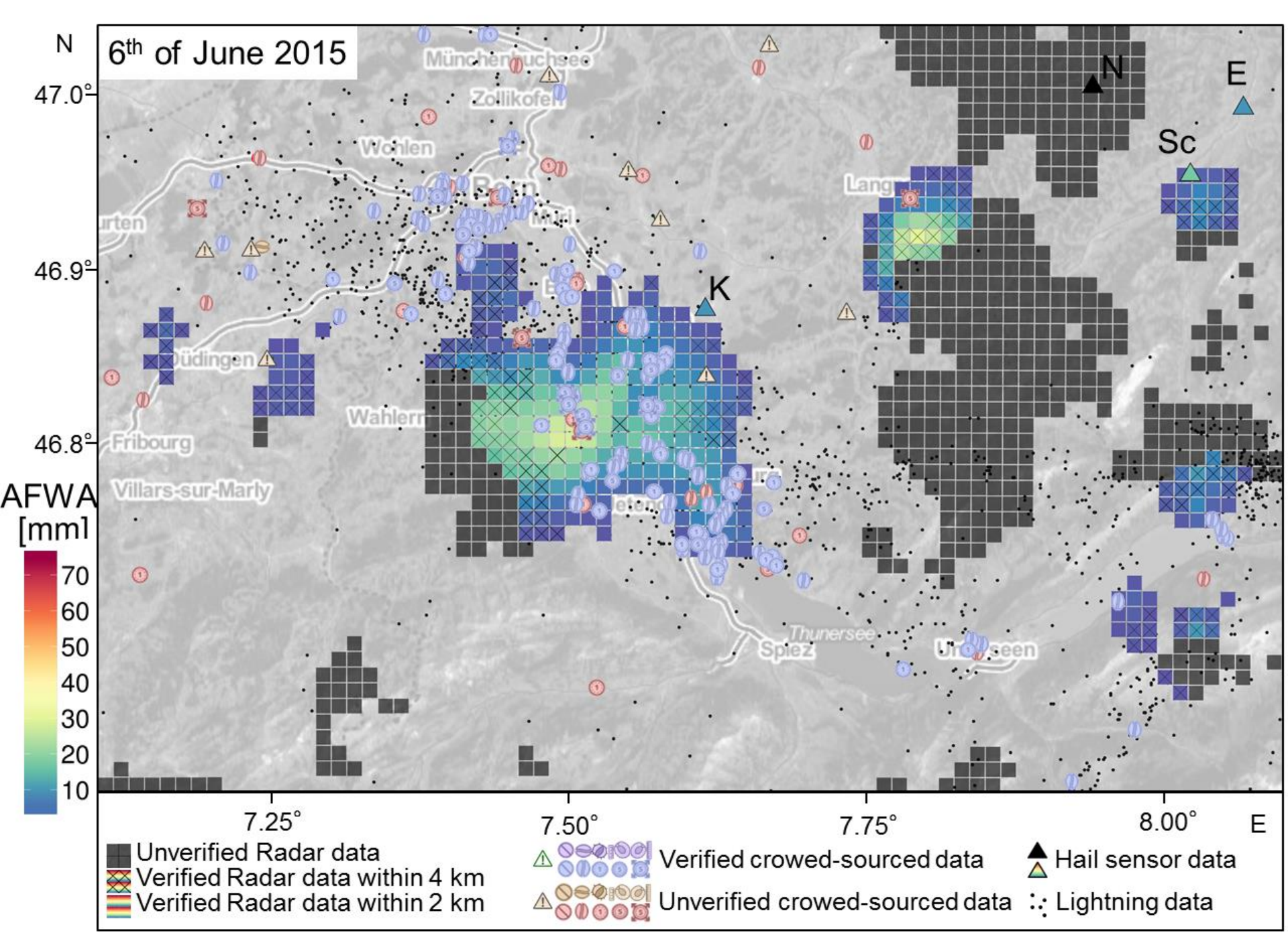
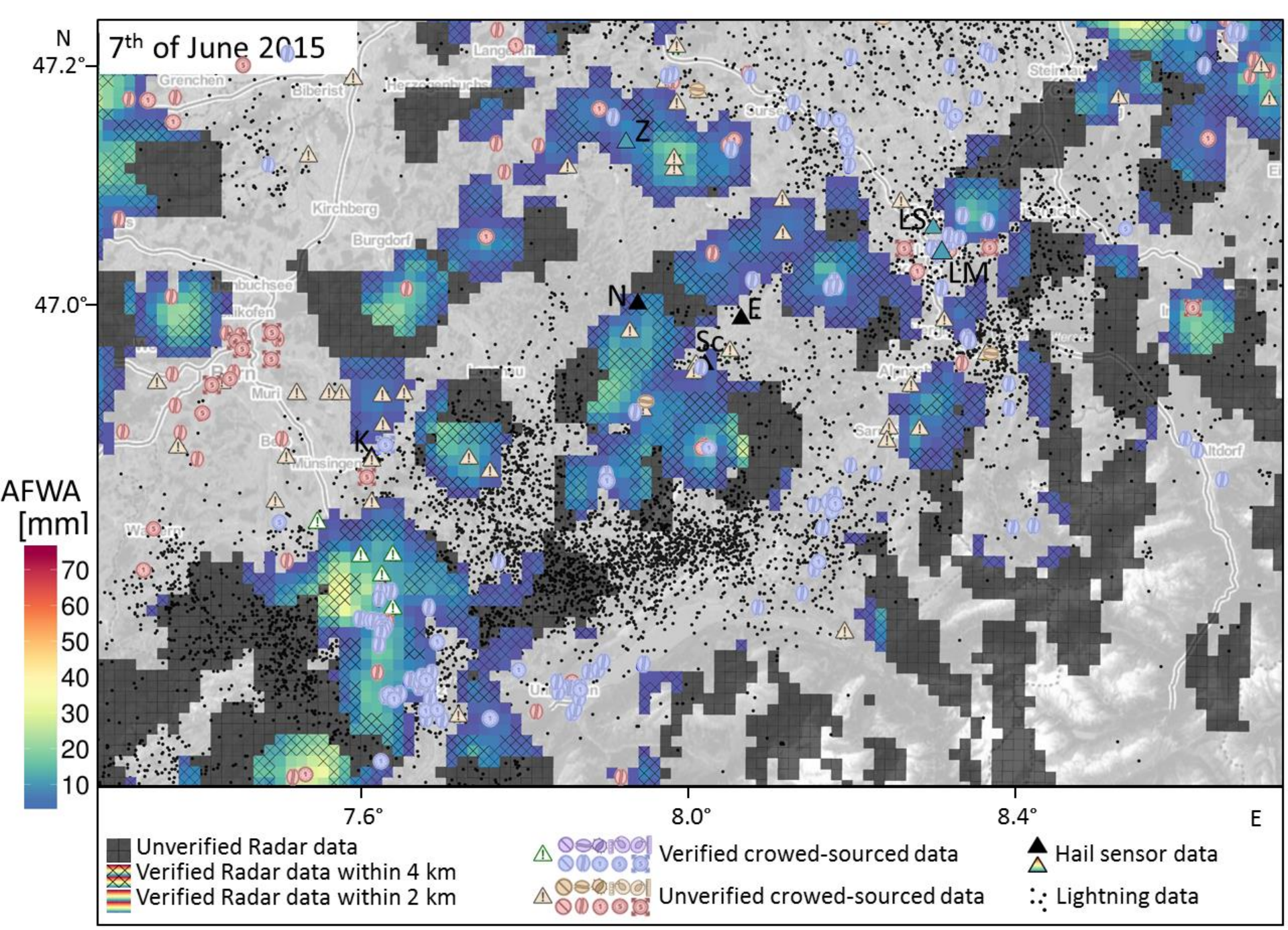
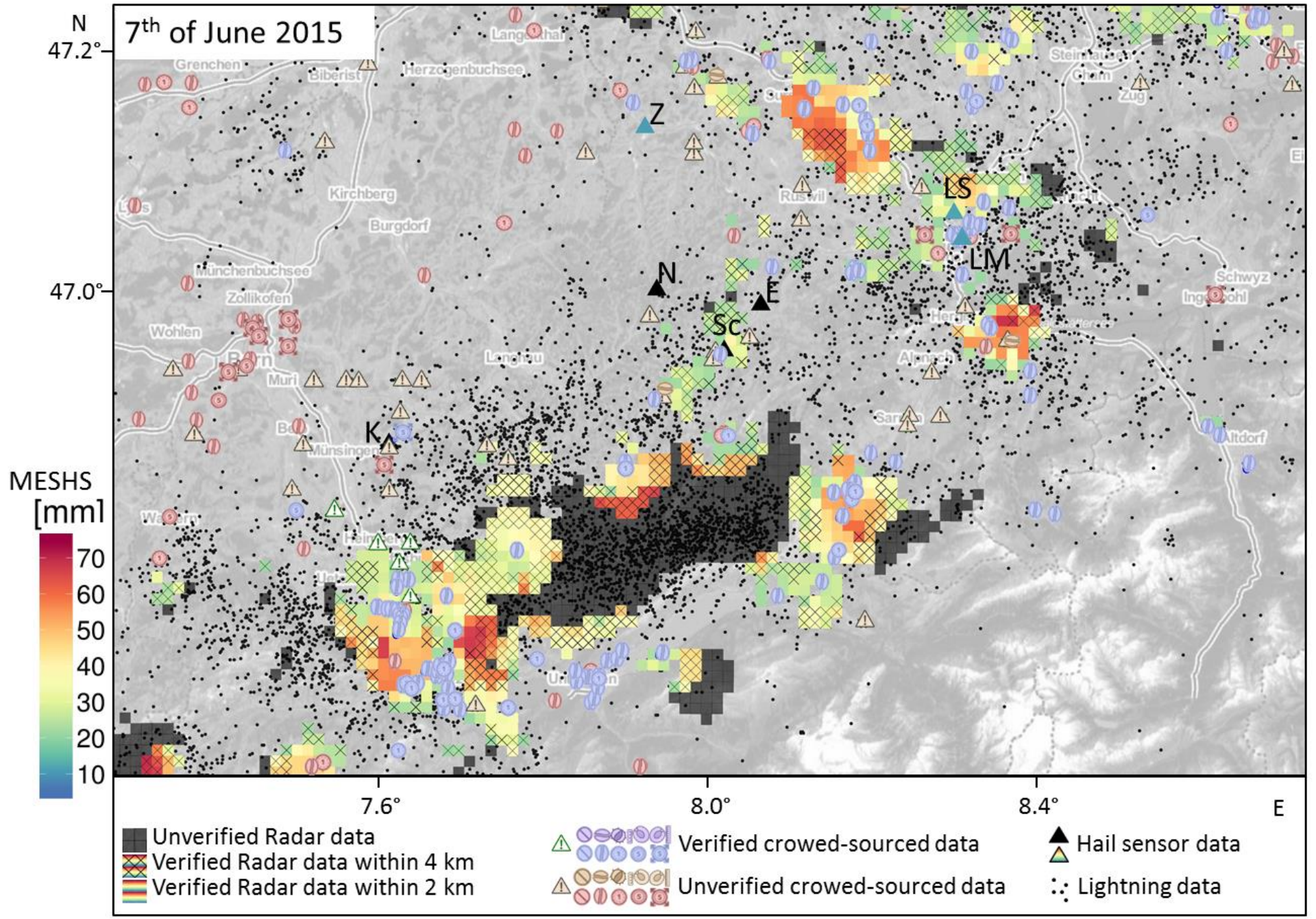

7th of June 2015
N
47.2°
47.0°
Z
LS
LM
N
E
Sc
K
Max Echo [dBZ]
70
60
50
40
30
20
10
7.6°
8.0°
8.4°
E
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data

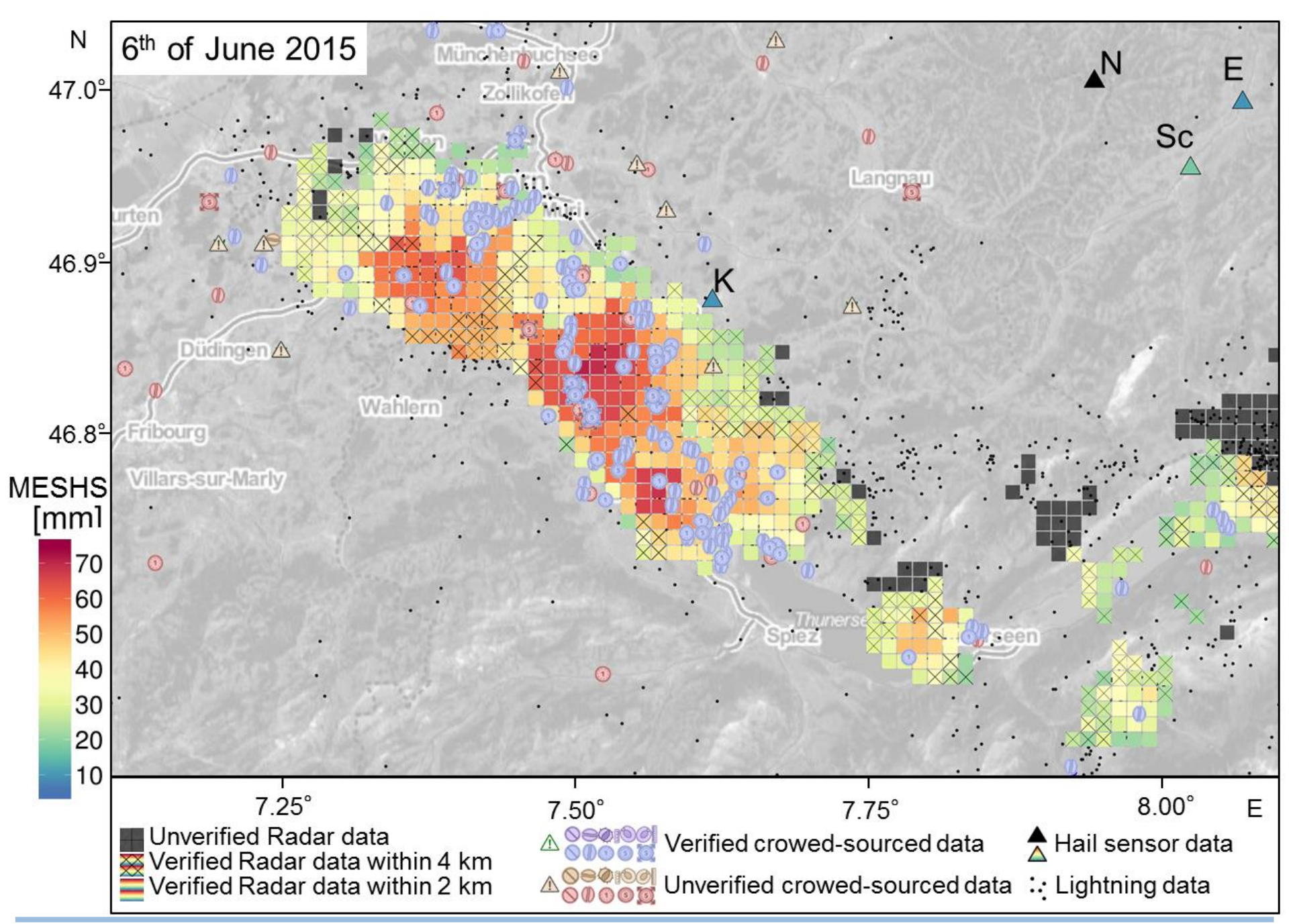

6th of June 2015
N
47.0°
46.9°
46.8°
7.25°
7.50°
7.75°
8.00°
E
N
E
Sc
K
Zollikofen
Wohlen
Langnau
Düdingen
Wahlern
Fribourg
Villars-sur-Marly
Spiez
Thunersee
AFWA [mm]
70
60
50
40
30
20
10
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data


7th of June 2015
N
47.2°
47.0°
7.6°
8.0°
8.4°
E
Z
LS
LM
N
E
Sc
K
AFWA [mm]
70
60
50
40
30
20
10
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data


6th of June 2015
N
47.0°
46.9°
46.8°
AFWA [mm]
70
60
50
40
30
20
10
7.25°
7.50°
7.75°
8.00°
E
N
E
Sc
K
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data


7th of June 2015
N
47.2°
47.0°
7.6°
8.0°
8.4°
E
Z
N
E
Sc
K
LS
LM
AFWA [mm]
70
60
50
40
30
20
10
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data


7th of June 2015
N
47.2°
47.0°
7.6°
8.0°
8.4°
E
Z
LS
LM
N
E
Sc
K
MESHS
[mm]
70
60
50
40
30
20
10
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data


6th of June 2015
N
47.0°
46.9°
46.8°
7.25°
7.50°
7.75°
8.00°
E
MESHS [mm]
70
60
50
40
30
20
10
N
E
Sc
K
Langnau
Düdingen
Wahlern
Fribourg
Villars-sur-Marly
Spiez
Unverified Radar data
Verified Radar data within 4 km
Verified Radar data within 2 km
Verified crowed-sourced data
Unverified crowed-sourced data
Hail sensor data
Lightning data

MESHS

	Matches		Mismatches		Total	
	#	%	#	%	#	%
*	260	2.9 %	8’549	97.1 %	8’809	100 %
	2’586	23.1 %	8’607	86.9 %	11’193	100 %
	1’045	26.4 %	2’909	73.6 %	3’954	100 %
	161	16.8 %	798	83.2 %	959	100 %
	65	3.6 %	1’753	96.4 %	1’818	100 %
Total	4’117	15.4 %	22’616	84.6 %	26’733	100 %

HS

	Matches		Mismatches		Total	
	#	%	#	%	#	%
*	979	11.2 %	7’767	88.8 %	8’746	100 %
	4’511	40.6 %	6’583	59.4 %	11’094	100 %
	1’351	34.3 %	2’588	65.7 %	3’939	100 %
	214	22.5 %	739	77.5 %	953	100 %
	125	3.6 %	1’677	93.1 %	1’802	100 %
Total	7’180	27.1 %	19’354	84.6 %	26’534	100 %